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FOR PROMOTING EXPERIMENTS IN
HORTICULTURE

ANNUAL REPORT

EAST MALLING
RESEARCH STATION

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Guide Demonstrator and Exhibitions Officer : H. C. CHAPELOW.

Horticultural Advisory Officer to Kent County Council : N. B. BAGENAL, B.A. (Cantab.).

Secretary : Miss M. K. GLOVER.

Shorthand Typists : Miss M. B. HOAD, Miss E. M. SHEPHERD, Miss E. D. SIMONS.

Visiting Days : Tuesdays and Fridays, or by special appointment.
Hours : 10-12 a.m. 1-5 p.m.

Station : East Malling Halt.

Bus Services from Maidstone every half-hour to *East Malling Church.*

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SECTION I

GENERAL DEVELOPMENT AND ACTIVITIES.

Section I

GENERAL DEVELOPMENT AND ACTIVITIES.

From certain points of view the year 1924 has been a notable one in the Station's history. The calls upon the services of the Staff have increased much more rapidly than could have been foreseen. They testify to the ever growing interest of the Horticultural community. These demands have necessitated the calling in of additional help. Those members of Staff appointed last October have had a full year in which to establish their lines of work and develop the Station's activities. As the work increases so do new necessities arise, and, if the Station's usefulness is not to be curtailed, normal and continued expansion must be allowed for.

Building Scheme.

When the Annual Report for 1923 was printed, it was reported that the original scheme was practically completed with the exception of the Director's house.

As it proved quite impossible to find sufficient accommodation in the neighbourhood for our growing Staff, the Caretaker's Cottage quickly came into occupation, whilst the Director, Secretary and Administrative Staff transferred their quarters from the Research Building to the Annexe adjoining the Cottage, in order to make room for the increased needs of the research workers, and to add to the quietness of that building. As a temporary expedient this arrangement has accomplished what was intended.

The Orchard House, Laboratory-Greenhouses, and Propagation House were in full use during the year and the Pathology workers are already indicating the need for more space and better facilities.

The only room of any size at the Station, which serves as Board Room, Library and Herbarium, Staff and Conference Room, Exhibit Staging Room, and Entertainment Room, has begun to prove inadequate for all these purposes. As the Library facilities have increased, so has the available space for other purposes decreased. Our large parties of visitors could only be entertained on the ground floor of the Oast House ; the amount of time lost in frequent shiftings of furniture and the planning of temporary expedients has been serious and only the cheerful adaptability of everyone concerned has made a difficult situation workable.

During the past two years, Dr. Knight (Physiologist), has been able to share a laboratory with Mr. A. M. Massee (Entomologist), but if either of these lines of work is to develop much further the accommodation will prove inadequate.

Whilst everyone is working with complete goodwill and efficiency, it is felt that some forecast ought to be made as to the difficulties likely to arise in the course of our development. It is to be hoped that one day a substantial endowment may come to relieve the situation. The fact has also to be faced that, after a few years, additions to buildings mean additions to maintenance, and there is now almost continuous work about the place for a carpenter and " odd job " man, but there is nowhere to accommodate him.

The building of the Director's house, which was the item in the Building Scheme chosen for postponement, has not yet been started, since sufficient money was not available for all needs at once. At the close of last year £600 was still required in order to earn the necessary complement from the Ministry of Agriculture on the recommendation of the Development Commissioners. A further £200 has actually been subscribed during 1924 and the major portion of the balance is in sight before the stipulated period for collecting the fund expires. A number of annual contributions have been promised. Unfortunately, the cost of building has very materially increased since the sum of £1,150 was earmarked for the purpose, and as it was impossible to build during the time when this tender held good, this difficulty has to be faced.

LAND.

In our report for 1922, the fact was pointed out that our plantings were likely to be curtailed shortly owing to the decreasing area of available land, and the necessity for retaining certain open spaces for field crops. This year we have reached our limit for the present, and, when the first forward trial of Sweet Cherries on known root-stocks became available in the Nursery, it was regretfully decided to ask the hospitality of a commercial grower for these trees and to retain the space ear-marked for Cherry trials until a complete series was ready—some three years hence.

This is but symptomatic of the problems ahead of us. As each experiment in the field develops, it requires more space than was originally anticipated because we are learning more about the lay-out of field experiments, the necessary unit of plants under any particular treatment, their best disposition and so forth.

There are two possible solutions to our difficulty. The most attractive, and most difficult of accomplishment, is the acquisition of more land. The other is the curtailment of our activities in the field, and the grubbing up of economically valuable and historically interesting areas, as soon as we have obtained our immediate Experimental aims. These latter are the lines upon which we are forced to begin working, but there is always the problem of deciding when we can afford experimentally to give up a plot, feeling confident that we shall get no more important results out of it.

There is also the obvious disadvantage to our exchequer in grubbing up highly productive areas. However, a beginning has been made in an attempt to reduce the Nursery side of our work. Considerable areas were necessarily occupied, for some time, in stool beds of the various named and selected stocks. These were essential whilst we were raising our own Experimental material in bulk. Moreover, other institutions relied on us for similar material and many of the Trade were only too anxious to obtain specimen plants for identification purposes and to serve as a nucleus for the propagation of further stock. From 1917 onwards we have endeavoured along these lines to give what help we could, and it is now felt that, in the case of the majority of the varieties, sufficient time has been given for all those who require specimens to satisfy their needs.

When we can reduce this stock-raising work to a minimum (and the development of our own Experiments must now take precedence), we shall have cleared another three or four acres to help us carry on.

At one time during the year our hopes were raised that our land problem might anyway be relieved to some extent from another direction.

In April, we were officially approached by the Ministry of Agriculture with a view to East Malling being selected as one of six centres for the systematic testing of Farm Crops, on a common plan to be formulated by the National Institute of Agricultural Botany. Certain proposals were made as to provision of funds to cover necessary cultivations, equipment and supervision, and the Executive Committee accepted these, subject to being able to come to a satisfactory arrangement with regard to the acquisition of a suitable area of new land. It was felt that by adopting this scheme we should be doing the best service possible for the Corn and Market Garden Growers of the country and that the opportunity offered both the individual attention of a whole-time recorder and the entire use of a new area of land. The Ministry of Agriculture was, at the time, very favourably disposed towards considering any reasonable proposition *re* the acquisition of a suitable extension of land for these trials. This would incidentally have automatically released some nine or ten acres of our present area.

Unfortunately our immediate neighbours decided that they could not see their way to assisting the scheme, and it therefore became necessary to look further afield. This involved many delays and protracted negotiations, and it was well into October before we were in a position to indicate to the Ministry any possible land. By that time, the Ministry had naturally considered the equally strong claims of other counties and institutions. We were unable to press our proposition as an especially advantageous one and so the negotiations had finally to be dropped. It was a severe disappointment to those of us who were as anxious to improve our field trials as to relieve our land problem.

ANNUAL MAINTENANCE GRANTS.

For the past academic year the maintenance grants received from the Ministry of Agriculture amounted to £6,300. In addition, the Ministry paid the expenses of our Exhibit at the Wembley Exhibition and a proportion of that at Birmingham. In addition to the annual grant of £200 voted from the Kent County Council, the East Sussex County Council has again made a contribution of £100. In drafting our estimates for the financial and academic year, we have of course to allow for a sum representing sales of produce. For the past few years this has been fairly constant, whilst showing a steady, if small, annual increase. It is to be hoped that this may be maintained.

COMMITTEE OF MANAGEMENT.

This is the third year since the present Committee of Management was appointed. Under paragraph 9 of the Articles of Association all appointed members automatically retire before the next General Meeting, but are eligible for re-election. During the year there have been no changes on the Committee. The Executive Committee was re-elected *en bloc* for the year.

STAFF.

There have been no fresh permanent appointments to the Research Staff of the Pomology Department, but Mr. F. Cheal, N.D.A., D.I.C., has been working on the Recording Staff during the winter months, until he can resume his field investigations upon Hop " Mosaic ". Mr. D. Hammond, who left us temporarily to take up one of the Ministry of Agriculture's Scholarships for Rural Workers at Cannington, has returned to equip himself as a skilled Propagator and Recorder. Mr. E. Ball, B.A., (Cantab.) who helped us last year, has taken up the position of Research Pomologist, at Long Ashton. Otherwise the Pomological Staff is unchanged.

Though it will thus be apparent that we have still to live to some extent from hand to mouth as regards the junior Recording Staff who assist us in collecting our field data, a considerable and welcome advance has been made in the methods of preserving and tabulating the actual records under the care of Miss A. D. Mackenzie.

If we are to continue this recording work as it should be done, and we are convinced of the ultimate value of the data, we must plead once more for a more generous recognition of this essential part of horticultural experimentation in the field by making these posts more attractive and hence permanent.

With the approval and assistance of the Ministry of Agriculture we were enabled in October to prolong the temporary appointment of our Exhibitions Officer, and combine it with that of Guide Demonstrator. Mr. H. C. Chapelow,

formerly of the South-Eastern Agricultural College, Wye, who came to us temporarily in the former capacity, has stayed on to fulfil both duties. He is thus becoming familiar with the history and geography of the main experimental plots and the economic application of results, and has already been able to deal with a number of visitors, so that, in the coming summer, the Research Staff should be much less interrupted.

During the busiest summer months, Mr. N. B. Bagenal (County Horticultural Advisory Officer) endeavoured to be at the Station on the Tuesday Visiting Days as frequently as possible, so as to assist us in showing round Kent growers. This was certainly a help, but the demands on Mr. Bagenal's services for visiting purposes in the County itself are so constant, and this work so important, that it is felt it must be given the preference.

In the Pathological work, Dr. Wormald was given valuable aid during the year by Mr. R. V. Harris, B.Sc., who came as a post-graduate worker (from the Imperial College of Science) at the end of 1923. He took part in the general activities of the department in 1924 and, in particular, undertook an investigation of Raspberry diseases, on which research was urgently needed. In October, the Ministry of Agriculture made a special grant to the Station which enabled Mr. Harris to continue this work. Such assistance, however, can only be regarded as temporary under the present arrangements, and it is highly desirable that it should become of a more permanent nature to ensure continuity of work, especially as certain other diseases came under notice during the year which would well repay a more intensive study than is possible at present.

As a result of the unavoidable discontinuance of the collaborated programme of work upon Woolly Aphis, following upon the transference of Mr. L. N. Staniland, A.R.C.S., from the Imperial College of Science to Long Ashton, Mr. R. H. Le Pelley, A.R.C.S., B.Sc., D.I.C., has come to us at the instance of Professor Maxwell Lefroy, under a temporary arrangement, in order to pursue the investigation. It is to be hoped, considering its economic importance, that, by some means, this work may be put on a more permanent basis. Fortunately for Mr. Massee, Mr. Le Pelley was able to come to us at a very busy moment in the Entomological work and rendered general assistance during December.

A welcome sign has been the desire on the part of post-graduate students to come here for considerable periods both to take up special lines of research in the the Laboratories and to gain experience in field experimentation. The value of such volunteer help is often considerable, since such temporary workers can be given more or less isolated problems to investigate, and it is cause for regret that owing to insufficient accommodation it has been necessary to refuse some such applications. East Malling, unlike most of the Research Institutions, is a detached entity, with no University Departments upon which to draw

directly for assistance of this kind, and now that advanced students are asking to come here it is a pity that we cannot take full advantage of the opportunities.

We should like to congratulate Messrs. J. Amos and A. W. Witt on taking the National Diploma in Horticulture whilst carrying on as efficiently as ever their multifarious duties at the Station. We are also glad to state that one of our former recorders, Mr. T. N. Hoblyn (of Wye), had been awarded one of the Ministry's Scholarships (at Cambridge University), to enable him to pursue the study of Statistics in relation to Agricultural and Horticultural Crops. We look forward to being able to welcome him back to East Malling on the completion of his studes to co-operate in analysing the valuable data accumulated here.

Mr. H. M. Tydeman has attended a Special Course of Training given by the Meteorological Office at the Kew Observatory relative to the best methods of recording Meteorological data.

COLLABORATION.

(*a*) *Plant Physiology.*

Dr. R. C. Knight, D.I.C., of the Plant Physiology Department of the Imperial College of Science, who came to us as far back as 1920, to pursue part-time investigations at East Malling into the problems raised by the root-stock work, has settled down whole-heartedly to the investigation, and has taken up his residence in the neighbourhood. This has enabled him, with the full concurrence of Professor V. H. Blackman, to take his share in the general life and thought of the Station. He is in addition collaborating with members of our Staff upon various other problems in which the physiological aspect looms large ; such problems, for instance, as vegetative propagation, the balance between root and shoot formation, and " Reversion " in Black Currants. We hope that, before long, under a similar arrangement, if facilities are offered, a Bio-Chemist may be associated with him in some of our problems. We confidently look forward to a further period of collaboration as successful as that which has just passed.

(*b*) *Hop Investigations.*

Prof. E. S. Salmon, F.L.S., and Mr. A. H. Burgess, B.Sc., of the S.E.A. College, Wye, continue to be closely associated with these experiments, the former as breeder and selector of the new varieties, and the latter from the chemical standpoint. We have again to thank Mr. F. C. Arnaud, F.I.C., County Analyst, for supplying the many analyses of the manures which have been applied.

Mr. F. Cheal, N.D.A., D.I.C., has for a second season continued his survey of the incidence and spread of Mosaic disease in our Tutsham garden under the direction of Professors V. H. Blackman and E. S. Salmon.

(*c*) *General Pomology.*

Plans have been made at the Long Ashton Horticultural Research Station, Bristol, for carrying on the arrangements formerly made with Mr. G. S. Peren, for the joint testing of Raspberry varieties under different soil conditions.

(*d*) *Genetic Work.*

The programme of work arranged in collaboration with Mr. M. B. Crane, of the John Innes Horticultural Institution, Merton, is developing satisfactorily. Many of his new seedlings propagate very readily and show other interesting characteristics. As is mentioned above, the tests of his Seedlings for immunity to Woolly Aphis were unavoidably interrupted for a period, however, arrangements have now been made to revive the work.

(*e*) *Pathological Investigations.*

Mr. F. T. Brooks, M.A., of the School of Botany, Cambridge, continues to take a very active interest in the field experiments designed to test the possibilities of evading " Silver Leaf " by the adjustment of cultural treatments and conditions. He is still following up the results of some of his inoculations at the Station.

Owing to the difficulty of obtaining suitable trees for the purpose, Mr. Grubb had in 1924 to abandon the fungicide trials which had been developing for some years in collaboration with the Department at Wye. However, Dr. W. Goodwin, of the Chemical Department of the S.E.A. College, once again took an active interest in the field trials with Winter insecticides, and East Malling made arrangements for testing in the field some new spray fluids supplied by Mr. F. Tattersfield, B.Sc., F.I.C., and Mr. C. T. Gimingham, F.I.C., of the Department of Insecticides and Fungicides, Rothamsted Experiment Station, Harpenden.

Outside Trials.

For one more year a fairly successful attempt has been made at taking detailed records on a number of the trial plots of trees on known stocks, and named varieties of bush fruits, which we established upon different soils and in different climatic conditions. In many cases the pruning of these plots and the picking of the fruit was also undertaken to ensure uniform treatment, and observations have been made at different seasons of the year. Mr. Bagenal has rendered us some assistance on the plots in Kent. It has been possible during the winter to summarise many of the results obtained from these records during the past four or five years, and, as they very generally bear out the results of our own more controlled plots to a marked degree, despite the very variable histories which such trees acquire under commercial conditions, we ought to be able in the near future to reduce this outside record taking very considerably. However, we are satisfied that the results when published will thoroughly justify the efforts made hitherto to record our detailed observations.

Mr. A. E. Burgess, Horticultural Superintendent for the Surrey County Council has, during the winter, been able to establish a number of trials of Black Currant varieties in his County.

Apart from these stock and variety trials, pruning experiments are being carried out on two commercial farms in conjunction with Mr. Bagenal. In four instances, the pathologists have also been testing control measures against certain diseases on commercial farms.

Meteorological Observations.

The necessity for keeping certain weather records has been recognised at the Research Station ever since 1914. On several occasions already their summarisation shed considerable light upon crop and growth phenomena. For instance, recourse was made to these records when drawing our conclusions as to the setting of Black Currant fruits; again, when Prof. Salmon came to review the cropping and resin contents of his new seedling Hops; and when Mr. Massee summarised his investigations on the control of Apple Blossom Weevil. When, therefore, we were approached by the Ministry of Agriculture, in conjunction with the Meteorological Office, to co-operate in a scheme which would involve the taking of systematic records upon certain crops and upon weather conditions, on a common plan by a selected series of Institutions, we gladly accepted the opportunity of putting this work upon a more comprehensive basis.

During the year, the negotiations were completed, and the Station was furnished by the Ministry with an anemobiagraph, for recording the direction and velocity of the wind, and with certain other recording instruments, since our own were not in all cases uniform with the agreed standard pattern. The Meteorological Office's own expert selected the sites for the recording instruments, and a special plot of trees and bushes is to be planted for the observations. We hope to get a full year's records for 1925.

Though the Ministry are making arrangements for the correlation of the two sets of records, of course considerable additional work is involved in taking some new and more frequent readings and in making the special observations upon selected plants, as required for the Horticultural and Phenological Branches.

Advisory Work.—Correspondence and Visits.

It is perhaps worth while once again to state quite clearly the position of this Station with regard to advisory work. We were not constituted by the Ministry of Agriculture as an Advisory Centre, but as a purely Research Centre, and we receive no official encouragement or monetary assistance on this account.

It is of course quite obvious that any successful Research Institution must attract enquiries as a result of its work, and it would be a deplorable sign if it did not. However, it must be fully realised that this work is being done

entirely by the Research Staff ; and a study of the figures given below will show to what an extent this valuable activity inevitably interferes with Research Work.

Despite the advent of an Horticultural Advisory Officer to the County of Kent, and his close association with this Station, it has fallen to the lot of the Pomology Staff here to answer by letter 630 enquiries, an increase of over 200 in a single year. This total does not include a considerable number of general queries addressed to us, but referred to Mr. Bagenal for reply.

During their first year's work, the Pathologist dealt with 92 letters of enquiry, and the Entomologist with 40, making a total for the year of about 760 advisory letters to be dealt with by purely research workers.

Since our Mother Institution, Wye, has Advisory Officers, and the County has appointed its own Horticultural Advisor, it will be understood that we are not likely to go out of our way to invite more of this correspondence than necessary, but by far the largest proportion of this work consists of queries arising directly or indirectly out of our own lines of research. An analysis of the pomological subjects dealt with in this correspondence will show how closely these follow the principal line of research carried on by the Station.

Principal subject of enquiry.	*No. of letters.*
Small fruits, varieties, cultivation, etc., Raspberries and Black Currants	143
Fruit tree stocks, uses, identification, etc.	109
Suitable soils, varieties, planning, etc., mainly in relation to above subjects	82
Propagation	42
Spraying, especially fungicidal	37
Pruning	13
Miscellaneous	204
	630

With regard to the origin of these enquiries, it is interesting to note that over half (393) came from the immediately adjoining Counties of Kent (214), Sussex (61), Hants (30), Essex (27), Surrey (24), Herts. (21), and Middlesex (16). The remainder were fairly widely distributed, and included a few from Scotland, Ireland and countries outside Great Britain.

For the past two years attention has been drawn to the increasing popularity of the telephone as a method of enquiry. Unfortunately, no exact record was kept during the past year of the number of such calls, but, at the present rate, they must have been between 200 and 300 for the year. This would bring our answers to enquirers to probably over 1,000 for the year, apart from those which we have referred to Mr. Bagenal.

Another aspect of this work which has been referred to in previous reports has also extended considerably. The identification of specimens, mainly of stocks and small fruits, is of course closely associated with the Advisory letters, but in a large number of cases the work involved does not terminate with a single letter. At the present time for instance, over sixty collections of specimens are being kept under observation in the " Identification " Plot.

With regard to actual visits to Farms, Mr. Bagenal's presence at the Station has completely altered the situation and we have been able much more effectively than ever before to follow up correspondence and chance conversations. Mr. Bagenal reports that he has paid 159 visits in Kent during the year, most of which originated in letters of enquiry to the Station, though many must have resulted from the direct contact that he has succeeded in establishing with the Growers through his winter lectures. Mr. Grubb has accompanied Mr. Bagenal on a number of visits and has also paid a considerable number individually. Other members of the Pomology Staff have recorded 54 Advisory visits, whilst the Pathological workers have paid 27, and the Entomological 10. These, of course, were not confined to Kent. Apart from Mr. Bagenal's work, then, our activities in this direction have here again more than doubled during the year.

These visits do not include several tours which have been undertaken with the special purpose of keeping in touch with Growers in more distant parts, and gaining information upon particular points. Once again three members of Staff (representing the Entomological, Pathological and Pomological interests), gave a portion of their summer holiday to making investigations in the Raspberry growing areas of Scotland (Perthshire and Forfar), when a number of Growers were visited, as well as the Royal Botanic Gardens, Edinburgh. On another occasion, a day's tour was arranged amongst the Soft Fruit Growers in East Sussex, for the success of which Mr. W. Goaring, the County Horticultural Superintendent, must be heartily thanked.

During the North of England Fruit Conference several fruit farms and districts were visited around York, and in the North Riding. Later in the year, a week was spent in Hampshire visiting some fifteen Growers with whom we had been in correspondence during 1924. Both Mr. C. H. Oldham, the Horticultural Inspector of the Ministry of Agriculture for the district, and Mr. C. J. Glede, the County Horticultural Superintendent, contributed very materially to the interest and success of this tour.

In one other direction we have tried to maintain the interest of Growers in our work. Mr. Bagenal, monthly, under " Notes for Fruit Growers " in the *Journal of the Kent Farmers' Union*, and the *F.B.G. Journal*, brings before Growers any seasonal topics of especial interest which may be occupying the thoughts of the Station.

VISITORS.

There has been a considerable increase over last year in the number of visitors shown round the Station in 1924. Though there have been fewer large parties of Growers coming as Associations, and though the usual Hop Inspection days were not advertised this year, there has been a steady stream of individual visitors. There appears to be a misconception that these activities are confined to the few summer months, hence it is thought worth while to give the actual details of these visits.

Month.	*No. of days on which visits were paid.*	*No. of visitors per month.*
January	8	70
February	7	17
March	10	21
April	2	3
May	20	75
June	12	134
July	22	197
August	22	239
September	13	60
October	14	23
November	5	14
December	9	27
Total	144 days	880 visitors

From this data it will be seen that, though the bulk of the visitors were from May to September inclusive, there was not a single month in which visitors were not coming. In all, 880 individuals, as against 789 in 1923, are actually recorded as having been shown round the Station ; and on 144 days (as against 133 in 1923) out of the 365, at least one Member of Staff, and often three or four, were occupied in showing people round. The number 880 does not completely represent the position for two reasons. First, a considerable number of visitors came for more than one day's inspection. They returned for a second and third day to be shown round. Secondly, a number of Kent Farmers now know the Station so well that they evade the Visitors' Book altogether, and make straight for their object. By these two methods well over 100 entries were omitted during the year.

Owing largely to the assemblage of overseas representatives in the country during 1924, there was a notable number of such visitors at the Station. Quite apart from the two International excursions to the Station arranged by the Chamber of Horticulture and the Ministry of Agriculture, one or more individual

travellers paid visits from Eastern and Western Canada, Australia and New Zealand, the Transvaal, the Cape, and the Orange River Colony, India, Ireland, Trinidad and Jersey, amongst our Colonies, Dependencies and Dominions. Visitors also came from both the Eastern and Western States of America, from Japan and Manchuria, Holland, Germany, Austria, Czecho Slovakia and the Azores. Since the majority of these overseas travellers were either Research Workers or practical Growers, considerable exchange of ideas was possible, with the result that many of these visits were most stimulating.

Upon the suggestion of the Chamber of Horticulture arrangements were made for the reception at the Station of the Conference Horticole Professionelle Internationale, at the end of May. The Chairman (Mr. W. R. Oldham) together with other representatives of the Chamber and the Horticultural Trades Association, accompanied the foreign guests. The very representative gathering of so many horticulturists of international reputation made the visit a very interesting and profitable one.

Early in July, Sir Daniel Hall, and other representatives of the Ministry of Agriculture, brought a body of visitors from the Permanent Committee of the International Congress on Agriculture and Dominion Agricultural Associations to East Malling. Though our guests were drawn from a great many nations, and had but a short time to spare, they visited the Station at a time of year when a variety of experiments were at an interesting stage, and from the number of questions asked, it would appear that considerable interest was aroused.

That Horticulturists of every type, and even a wider public, are becoming genuinely interested in fruit research and its application to practice, is shown by the very diverse parties which visited the Station during the past year. These included the Horticultural Sub-Committee of the East Sussex County Council, the Rochester, Sandhurst, Northiam and Hawkhurst Branches of the Farmers' Union, the East Sussex Growers' Association, the Sevenoaks Gardeners' Society, the London School Gardening Association, the Ashford and District School Teachers' Association, the Mid Kent Natural History and Philosophical Society, and the Kent Branch of the British Medical Association.

Parties of students from the S.E.A. College, Wye, and from the Horticultural College, Swanley, paid visits as usual.

Visit of the Ministry of Agriculture's Horticultural Inspectorate.

In addition to the above visits, a notable and very pleasant feature of the year was a visit from the Ministry's Inspectorate from the 30th June (Monday) to the 4th July (Friday). The gathering was arranged to familiarise them with the research work in progress at the Station. A prearranged programme of visits to the main experimental plots was interspersed with Conferences upon the experimental results obtained. It was unanimously agreed that the interchange

of ideas and the arousing of new interests was mutually beneficial. The meeting throughout was marked by good fellowship and mutual understanding, which we hope will prove as valuable to our visitors as it has to ourselves.

As will be seen under the section dealing with the Library, our guests showed their appreciation in a very practical manner by a presentation that will be much valued at the Station.

LECTURES, DEMONSTRATIONS AND CONFERENCES, ETC.

Apart from addresses given at the Station itself, the following lectures have been delivered by members of the Research Station Staff :

Ministry of Agriculture's Whitley Council.
Wadhurst and District Farmers' Club (two lectures).
Tonbridge Branch of N.F.U.
East Sussex Growers' Association at Hastings.
North of England Horticultural Society, Harrogate (two lectures).
The London School Gardening Association.
Maidstone Natural History and Philosophical Society (two lectures).
The Sevenoaks and District Gardeners' Association (two lectures).
The Westerham Gardeners' Association (two lectures).
The Brasted Gardeners' Association.
The British Broadcasting Company (under the auspices of the Ministry of Agriculture).
Conference at the Midland Agricultural College.

This total of seventeen shows an increase of seven on last year.

In addition to the above, Mr. Bagenal has arranged a special course of five lectures based largely on the experimental results at East Malling. This series of lectures is being given at three centres during the winter of 1924-25 and it has undoubtedly not only helped to spread the results obtained at the Station, but has also relieved the Research Staff considerably from potential outside lecturing calls.

During the year Mr. Grubb and Mr. Bagenal gave three pruning demonstrations. One was held as usual on the pruning plot at the Research Station. About sixty growers and tree cutters attended. A new feature has been the other two demonstrations which were given on Commercial plantations in different districts. Thus a two-fold object was attained, the wider dissemination of the deductions which have been obtained from our experiments here, and the making possible of growers themselves participating in the pruning and demonstrating their own ideas. One gathering was held at Marden in January and was attended by about 75 persons. The second, held at Barming in December, was attended by about 150. These figures speak for themselves as to the success of the experiment.

Mr. Witt has given a number of demonstrations in budding, grafting and other methods of propagation both to individual enquirers and to parties of visitors at the Station.

The annual conference of research, advisory and educational horticulturists in the South-Eastern area was held at Wye in June. Eleven members of the Staff and Mr. Bagenal attended it, and several contributed to the discussions. The main topics dealt with were recent advances on the control of diseases and pests.

Later in the year an informal conference on fungicidal spraying was also held at Wye, and was attended by three members of Staff.

Representatives of the Station also attended the Imperial Mycological and Botanical Conferences and the R.H.S. Conference on new varieties of fruit.

During the year the Station was also represented on eight Committees of one sort or another.

EXHIBITS.

With regard to the staging of Educational Exhibits, the past year brought exceptionally heavy calls. First there came the invitation to put up an exhibit in the gallery reserved for the Ministry of Agriculture in H.M. Government Building at the Imperial Exhibition at Wembley.

The planning of this exhibit was of an exceptional nature, both because of the very limited space allowed, and the requirement for the presentation of the results of our researches " in story form."

Mr. H. C. Chapelow, formerly of the S.E.A. College, Wye, came early in 1924 to help us at East Malling in working out the details of this exhibit, and to his very great care its undoubted success is largely due. The official report of our Wembley exhibit says that it attracted much attention.

Fortunately for us, Mr. Chapelow was able to stay on after the Wembley Exhibit had been staged in April, to assist in the preparation, staging and explaining of our other exhibits.

There followed the three days Show at Chelsea in May, where a comprehensive exhibit of Stocks for Stone Fruits and Small Fruits was staged. Two members of Staff were in attendance throughout ; this attendance was made well worth while by the fact that the H.E.A. were meeting at Chelsea ; this enabled us to keep in touch with many of the County Horticultural Advisers. There were of course also a large number of English and Continental Nurserymen interested in the exhibit.

The second Kent County Show was held at Ashford. There we were able, through the kindness of the Agricultural Education Committee, to obtain a sixty foot run of staging with background. This, the largest space we have as yet been allotted, enabled us to stage a very complete exhibit. Many growers

showed their appreciation by spending an hour or more at a time going through the exhibit in detail, whilst others paid several visits during the Show. Two or three members of Staff were kept busy for the whole three days. A non-competitive exhibit of small fruits, Black and Red Currants and Raspberries, was also put up in the Soft Fruit tent with Mr. Bagenal's aid. The object was to arouse interest in the proper nomenclature of the different varieties.

In order to break fresh ground and get in touch with the problems of Northern Growers, the invitation of the North of England Horticultural Society to stage an exhibit at their Show in Harrogate in September was accepted. A replica of our Wembley exhibit, only on a larger scale, was here staged, and one member of Staff remained in attendance during the three days. Interest was certainly aroused and new connections made. The Northern Society showed its appreciation in a very practical manner by voting a contribution towards the expenses incurred.

For the Imperial Fruit Show at Birmingham, which as usual lasted eight days, a largely new exhibit dealing with Plum and Cherry Stocks and diseases of these fruits was planned. Though the General Election rather interrupted the attendance, a considerable amount of useful work was accomplished each day. During the period three members of Staff were in attendance at one time or another. In addition, at both this and the Ashford Show, Mr. Bagenal was able to help us at our Stand from time to time.

Our Exhibition material has been brought up to date and methodically catalogued during the past year, but we are much in need of a proper room in which to store and stage our different exhibits. At present the work has to be carried on under considerable difficulties and is subject to interruptions.

Staff Meetings.

The policy of holding periodical informal discussions on current research problems is being continued and there is a programme of ten meetings for the Winter Session 1924-25. Mr. T. Wallace, M.C., M.Sc., of Long Ashton, attended a discussion on " Leaf Scorch " and contributed an account of his work on the problem. The interest in these discussions is maintained as is shown by the regular attendance of twelve to fifteen members of the Staff.

Library.

The increase in the size of the Staff at the Station, coupled with the lack of access to any established Library, has made it essential that the Library shall be extended in scope and enlarged to render available more complete series of reference books, research publications, and periodicals, representative of all branches of the Station's interests, than has hitherto been either necessary or possible.

The current year has witnessed considerable additions of all classes of scientific literature, especially of periodicals, to the library.

We are greatly indebted to the following gentlemen for valuable presentations, not only on account of the intrinsic worth of the books, but also on account of the generous and appreciative spirit which prompted the gifts :

Mr. E. A. Bunyard
Mr. W. F. Emptage
Mr. A. M. Massee
Prof. E. S. Salmon

and the Horticultural Inspectorate of the Ministry of Agriculture.

With the increase in the size of the library it has been deemed advisable to appoint a small representative committee which is responsible for all questions relating to its welfare. In this way it is hoped to maintain the efficiency and availability of the collection.

Section II

The Farm.

Section II

THE FARM.

The year 1924 was chiefly notable on the farm for the very heavy crops of Hops and small fruits. Our three acre garden of Tutshams yielded an average of 31¼ cwt. per acre, and several of Prof. Salmon's new varieties cropped even more heavily. Out of our experimental garden of six acres, we actually marketed 186 cwt. of hops. Owing to the heavy crops, towards the end of the season the hops went off badly before we could finish picking.

Both Black Currants and Raspberries also cropped very heavily. The year will always be remembered as a Boskoop Giant year; our trial bushes, interplanted amongst bush apples, were actually cropping at the rate of over 3½ tons per acre. Baldwins came a good second with well over 3¼ tons, and Goliath produced just over 3¼ tons. Seabrooks was just over 3 tons, and even French (Merveille de la Gironde) was nearly three tons per acre.

As will be seen from another part of this Report (see page 75) our Raspberry crops were exceptionally high for our conditions. Lloyd George was our highest at nearly 3½ tons per acre, whilst twenty-four other samples of sixteen other varieties cropped at a rate of over 30 cwt. to the acre; four of these were actually over two tons.

The apple pruning plot gave us the biggest crop of fruit we have yet had, and the apple stock trials are now generally approaching cropping age. Unfortunately, seasonal conditions favoured the rapid spread of apple scab and rendered effective spraying almost impossible.

Finally, a severe hailstorm in August damaged the Apple crop very considerably, and made any storing impossible.

Our young Victoria Plums cropped well, and gave very clear indications of stock effect in this respect.

Amongst the fresh plantings on the farm were a further half acre of experimental hops (all commercial varieties), a trial of dessert varieties of apples, as very dwarf fillers on Jaune de Metz Paradise Type IX. These included Cox's Orange Pippin, Belle de Boskoop, Laxton's Superb, Northern Spy, Heusgen's Golden Reinette, Upton Pyne, Sturmer Pippin, Easter Orange and Ellison's Orange.

Rows of our chief varieties of black currants, raised from a single bush, were also planted out to serve as the future source of all our experimental stock.

Seven varieties of Plum—Blaisdon Red, Yellow Pershore, Cambridge Gage, Kea, Warwickshire Drooper, Magnum Bonum and Bastard Victoria, raised on their own roots, for comparison with others raised on Common Mussel stock,

were planted out. A plot of Newton Wonder and Allington Pippin Apples as half standards, on a series of vegetatively raised " free " growing stocks, was interplanted between our Plum Trials.

Time has rendered it impossible this year to complete the Guide to the Station by giving the maps and details of the trials on Egham Field, but it is hoped that this may be ready at least in part by the time our next report is issued.

Section III

Programme of Research with Brief Progress Reports, Surveys and Signed Articles.

Section III

PROGRAMME OF RESEARCH WITH BRIEF PROGRESS REPORTS, SURVEYS AND SIGNED ARTICLES.

Introductory.

In presenting a brief report of the results obtained during the past year, a point which has caused considerable difficulty and one which is likely to recur each successive season should be stressed. The very nature of the material which is under investigation in the field, and the methods which are being applied make inevitable a gradual accumulation of results, which in any particular year are not very striking. The whole process is one of gradual unfolding.

Under the circumstances, therefore, a choice has to be made between the annual repetition of a considerable body of detail, and the selection of particular lines of work where the accumulated records justify the drawing of preliminary deductions.

In this report the latter course has been adopted, though it is fully realised that this will mean great variability in the length and interest of this report from year to year.

Part I

Pomology

Part I

POMOLOGY.

By R. G. HATTON and N. H. GRUBB.

Programme of Research with Brief Progress Reports.

I. In relation to the Tree Fruits.

Root Stock Investigations.

1.—Stocks for Apples.

It has once more been possible to collect records designed to give a complete picture of the tree's activities. The fact that these trees are now rapidly coming into cropping, and that some have actually reached the stage of having an " off " year, has greatly enhanced our previous knowledge of the effects of root-stocks, the main influences of which are certainly emphasised. As each year passes, the control of the tree which can be established through the roots becomes more and more striking, and the importance from the point of view of both the grower and research worker more and more obvious. An entirely new manifestation of stock effect, which was foreshadowed by the behaviour of the stocks themselves, is their influence on the trouble known as " Leaf-Scorch". It was possible this year to collect statistical proof of these comparative differences. An article dealing with this subject was published in the *Journal of Pomology*, on page 65, Vol. IV., No. 2. It is reprinted on page 41.

2. Stocks for Pears.

(*a*) *Quince Stocks.*

The original plot of five-year-old trees continues to demonstrate the utter unsuitability of certain quince stocks for pears ; but until the trees come into cropping, there is not likely to be anything further to report with regard to the more suitable stocks. A younger series of trees designed to check and supplement this plot has demonstrated this season that it very generally corroborates the early results in the direction of " incompatibility."

(*b*) *Pear Stocks.*

This year for the first time, pears worked upon a series of selected and vegetatively propagated pear stocks have been available. The present appearance of the trees warrants the supposition that there are startling differences in the suitability of these selections, at least for the variety so far worked on them, Dr. Jules Guyot. Layered pear stocks are now being obtained in sufficient quantities for a greatly extended trial.

(*c*) *Other Rosaceous Stocks.*

Two varieties of pears have now been established on a wide range of rosaceous species, and this year some of them have been heavily fruiting. Evidence is accumulating on the suitability and unsuitability of these species as stocks.

3. Stocks for Plums.

The trial plot of Victoria Plums upon different root stocks blossomed and cropped freely this year, so that it was possible to add very considerably to the knowledge already acquired of the influence of these root-stocks.

A number of other varieties also blossomed freely and began to crop this year. This made it possible for the first time to follow out the extent of this influence upon different varieties. There no longer remains any doubt that stock does influence the vigour and cropping and time and habit of blossoming of Plums in sufficient measure to be of economic importance to the grower.

From a nursery point of view, some valuable data have again been collected with regard to incompatibility between certain plum stocks and certain varieties. Especially noteworthy is the fact that from amongst the seedling " Myrobolan " and " St. Julien " plum stocks different selections have shown widely different degrees of " incompatibility " with certain varieties.

4. Stocks for Cherries.

The first series of layered cherry stocks in preparation for the trial of sweet cherries have now been " run up " standard high for grafting. These not only reach the desired height a year or more earlier than is usual with seedlings similarly run up, but also have attained a measure of uniformity hitherto unknown. This year the selections also showed a very great diversity in type of root. For further details see page 87.

Contributory Factors Affecting Root Development.

The studies of contributory factors affecting root development and influence have, in several instances, been much developed, and a considerable amount of freshly prepared material awaits examination this winter. The phenomenon mentioned in the last Annual Report of the browning and shrivelling of the remaining leaves on trees cut down at different periods during the active growing seasons has again been observed on a similar scale.

Double Working.

The double worked apples, now six years old, produced their first considerable crop this year. Much information was collected as to the possible influence of the intermediate variety on the fruit. In nearly all cases, there seems to be evidence of an enhanced influence as a result of a greater length of " intermediate."

Pruning Experiments with Apples.

The Pruning Plot, now in its tenth and eleventh year, is approaching its full productive capacity; the crop this year, though of poor quality, was nearly double in quantity the best previous crop. As a result, the investigation is somewhat changing its direction, from the original problem of bringing the tree into bearing, and is now turning towards a study of the influence of pruning on the quality of the fruit, the regularity or otherwise of bearing, and the vigour of the tree.

The apparent influence of pruning on the development of leaf-scorch, and the fact that 1924 brought an exceptionally severe attack of this trouble, led to a careful study of its incidence on the pruning plot. The result of this investigation showed that the "tipped" trees were nearly always less scorched than the "untipped" trees; and a closer examination of the data strongly suggests that this effect of "tipping" is correlated with the lighter cropping up to the present of the "tipped" trees. This is discussed in detail on page 48.

The records from the Pruning Plot have this year been examined with a view to discovering their experimental errors. A very striking feature of this analysis is the fact that the variations among the trees on mixed seedlings "crab" stocks (although rigidly selected at the time of planting) are in nearly all cases very much greater than among those on comparatively uniform "paradise" stocks. This difference is so great that in some cases a result to be reliable would require nearly thirty times as many trees on "Crab" as on "Paradise."

Manuring of Apples.

Data on the incidence of leaf scorch were also obtained from the manured and unmanured stock trial plots. Whilst the same varieties on the same stocks were found to be scorching on both plots, the amount of scorching on the unmanured plot was, in most cases, double that on the manured plot. There seems every reason to think that all of these results will eventually be found to fall in line with the nutritional theory of the causation of leaf scorch.

THE BUSH FRUITS

Black Currants.

In the variety trials, owing to the exceptionally favourable season for Black Currants the potentially heavy cropping of Boskoop Giant was for the first time in ten years fully realised, the yield of fruit per bush exceeding that of Baldwin by about 9 oz.

This season a number of new named sorts, which have been sent in for trial have been described and classified. Variations from the main types are generally speaking negligible.

Valuable results are now beginning to be sent in from the trial plots of black currants, which were established in various centres, upon different soils. On all the lighter classes of land, and even some of the heavier ones, the Malling results are fully borne out. On some of the heaviest soils, Baldwin loses pride of place, owing to its lack of growth. But since it could be planted much closer than other varieties, if so treated, it will still probably be the most productive.

Crop weight records from individual bushes have now been accumulated over a period of four years, on several thousand plants. They represent all the principal varieties under various treatments. These figures have been subjected to a preliminary statistical study. As a result it is now possible to state with some confidence the number of bushes required to give a reliable experimental result under given conditions. Although the effective unit indicated by these results is not excessively large, it has been thought desirable this year for the first time to establish a plot of clone races of black currants in order to try and reduce the variation amongst the bushes to narrower limits. On page 54 will be found an article reprinted from the *Journal of Pomology* dealing with this question.

Some of the new seedlings showed considerable promise, and other large batches of known parentage came into cropping for the first time. This made it possible to carry the study of the inheritance of characters to its most important economic conclusion. The reciprocal crosses of Baldwin and Seabrook's are, from an economic standpoint, giving us the highest percentage of valuable new sorts. For the control of Big Bud in the field see the Entomological Part IV., page 158.

Raspberry Investigation.

Further progress has been made in the work of classification by the identification of two or three rather widespread varieties which have hitherto proved somewhat elusive.

The second year's crop of the main trial has again emphasised the wide difference in economic value between different varieties, at least in our conditions; on the whole, the order of cropping is roughly the same as in the previous year, with certain alterations of detail. A number of more recent additions to the collection cropped for the first time; several, and one in particular, give high promise of proving valuable acquisitions. The performance of individual varieties is discussed on page 75.

A considerable number of raspberry seedlings cropped for the first time. When every allowance is made for "seedling vigour" it may safely be said that several of them are very promising, particularly in the family, Pyne's Royal self-pollinated.

FIELD OBSERVATIONS ON THE INCIDENCE OF LEAF SCORCH UPON THE APPLE.*

By R. G. HATTON and N. H. GRUBB.

Although it has long been obvious that valuable information on Leaf Scorch could be obtained indirectly from field records, no attempt has been made at East Malling to deal fundamentally with the subject, because no satisfactory means have existed for carrying out the necessary detailed work.

Several of our other investigations (such as Root-Stock, Pruning and Manurial Experiments) have revealed factors tending to modify the incidence and development of Leaf Scorch. The records concerned with this aspect gathered over a period of six years have been collected together and summarised with the object not so much of stating the whole case, or of drawing general conclusions, as of directing attention to these factors, which cannot be ignored in building up a theory as to the causes of the trouble, and the most hopeful remedial treatments. The writers have, from time to time, been assisted in the collection of these data by Messrs. G. S. Peren, G. C. Maltby and various members of the present recording staff. These observations culminated in the present year (1924), in the most serious attack of the trouble yet experienced here, which has naturally led to the completion of the picture.

The Influence of Root-Stock.

The first of these factors is the influence of Root-Stock. Soon after the different varieties of " Paradise " had been identified, it was observed that certain of them showed a marked tendency to Leaf Scorch on the young shoots of the stool beds. A row of unpruned specimen " Paradise " Stocks grown for fruiting upon their own roots exhibited the same differences. In both cases, the so-called Improved Doucin (Amelioré, Type V.) was outstandingly affected ; occasionally the fruiting trees of the True Doucin (Type II.) showed the same tendency to a much lesser degree. In their early years, the young trees on these stocks scarcely showed this tendency at all ; in the sixth year (1923) of these Stock trial trees, however, the first signs of " Scorch " were noted.

In the sixth year of the growth of the varieties Bramley's Seedling and Worcester Pearmain, the manifestations were sufficiently striking to warrant the counting of the scorched leaves. These revealed notable differences amongst trees of a single variety, according to the stock on which they were worked. The

* Reprinted from the *Journal of Pomology and Horticultural Science*, Vol. IV., No. 2.

frequent reduplication of small plots upon the ground, and the interplanting of Bramley and Worcester, sometimes on the same stock, sometimes on different stocks, side by side, entirely precludes the possibility of attributing the different manifestations to soil variation. On certain plots "scorched" and "unscorched" trees alternate with great regularity according to the stocks upon which they are worked. The following map illustrates the situation :—

TABLE I.

Map showing arrangement of Trees on Plot XIV.

(*a*)	Bramley on I	Worcester on V	Bramley on I	Worcester on V
	Worcester on V	Bramley on I	Worcester on V	Bramley on I
(*b*)	Bramley on V	Worcester on I	Bramley on V	Worcester on I
	Worcester on I	Bramley on V	Worcester on I	Bramley on V

Both-(*a*) and (*b*) are twice repeated upon this plot in different positions.

In spite of this arrangement, the trees of each variety upon Type V. (Doucin Amelioré) showed more than twice as many "scorched" leaves per tree as those on Type I. (Broad-leaved English). The actual figures are as follows :—

TABLE II.

Average number of "scorched" leaves per tree, 21/7/1924.

(16 trees in each group.)

Variety.	Root-stock.	I.	V.
Worcester Pearmain		34	81
Bramley's Seedling		52	117

The real percentage difference is probably even greater than that shown in the table, since it was estimated that the total number of leaves upon the Type I.'s was considerably greater than upon the Type V.'s. In addition, the detailed records show that the degree of "scorching" was worse upon the trees on Type V.

The same varieties worked upon other stocks, such as the vigorous Type X., showed even less "scorch" than those on Type I., no badly "scorched" leaves at all being recorded. A plot of Lane's Prince Albert, a year older and rather differently arranged, showed an equally striking result. Here the trees are planted as below, and the figures entered on the map speak for themselves.

TABLE III.

Showing arrangement of Lane's Prince Albert Trees on Plot X.

	26		24		22	
S.	V.	S.	V.	S.	V.	S.
	80%		50%		40%	
24	25	12	5	2	6	5
V.	V.	III.	III.	III.	III.	III.
40%	70%	5%	1%	1%	1%	1%

Roman numerals indicate Type of Stock.
Figures above Roman numerals indicate mark based on count of " scorched " leaves.
Figures below Roman numerals indicate estimated per cent. of leaves " scorched."
S. indicates standard trees not included in survey.

A general survey of this Plot, where the trees on different stocks are planted more or less in parallel rows, showed that " scorched " and " unscorched " trees often alternated. This general examination revealed :—

Trees on	Type	I. Broad-leaved English.	Very little scorch.
,, ,,	,,	II. Doucin.	Some scorch.
,, ,,	,,	III.	Little scorch.
,, ,,	,,	V. Improved Doucin.	Much scorch.
,, ,,	,,	VI. Nonsuch.	Very little scorch.
,, ,,	,,	VII.	Considerable scorch.
,, ,,	,,	IX. Jaune de Metz.	Little or no scorch.
,, ,,	,,	X.	,, ,, ,,
,, ,,	,,	XIII. and XVI.	,, ,, ,,

This was repeated at both the pruned and unpruned ends of the plot.

There is every indication that these results will be generally borne out on a very different type of soil. The early records on our Stock Trial Plot on the Weald Clay in Sussex give the following percentages of " scorched " leaves for three varieties on different root-stocks.*

TABLE IV.

Percentage of " Scorched " Leaves on similar trees on Weald Clay.

On Stock.	Lanes.	Worcester.	Bramley.
I.	(10) 6	(7) 0	(10) 0
II.	(10) 4	(5) 13	(6) 3
V.	(10) 28	(4) 16	(10) 7
Long Ashton No. 5	(8) 0	(10) 0	(8) 0

The figures in brackets indicate the number of trees from which the record has been taken.

Turning to a much older plot of trees at East Malling, the Pruning Plot, we find our results largely corroborated. The trees on this plot are the only ones at the Station bought through the ordinary Trade channels, and little was known about their root-stocks at the time of planting, except that certain trees were

* Since the above was written, very striking confirmation has been obtained from a number of different soils in Hampshire.

on " Paradise," others on " Crab." At least six years ago " scorching " was becoming very evident upon this plot, especially on many of the groups of trees on " Paradise." By means of suckers and root-cuttings, a considerable number of these " Paradise " root-stocks have now been identified. Whilst in some cases the varieties of " Paradise " are badly mixed, in at least three instances it seems probable that trees are on pure lines of Types II. and V. As far as the root-stocks are known, these trees only too well confirm the points brought out on the Stock Trial Plots. The fact that these " Paradise " trees are mainly upon those types of stock which we associate with " scorch " makes the comparison of these trees with those on Seedling " Crab " extraordinarily interesting.

The estimated percentage of " scorched " leaves on four varieties on " Paradise " was 53.5, and on the same varieties on " Crab " was only 23.8. Below are given the detailed figures showing that in no instance is the estimated percentage less than twice as great on " Paradise " as on " Crab."

TABLE V.

Showing Percentage of " Scorched " Leaves on Varieties on " Paradise " and " Crab."
(32 trees in each group.)

	" Paradise."	" Crab."
Grenadier	72	36
Gladstone	65	32
James Grieve	61	25
Worcester Pearmain	16	2.5

Of course, the relationship of cropping to " scorch," referred to later in this paper, may have an influence contributing to this result. It must not, however, be concluded from this that the trees on Seedling " Crab " are uniformly freer from " scorch." Though the sets of trees on " Crab " were rigidly selected at the time of planting, they show an amazing lack of uniformity as compared with the sets on comparatively true " Paradise." This is well illustrated in the following tables :—

TABLE VI.

Showing estimated percentage of " Scorched " Leaves on Gladstone, unpruned.

Tree No.	On " Paradise " V.	On " Crab " (seedling).
1	70	18
2	80	70
3	80	40
4	80	80
5	80	20
6	90	12
7	100	32
8	100	90

TABLE VII.

Showing average deviation from mean (as percentage of mean) of three varieties on "Paradise" and "Crab."

	Unpruned.		Pruned.	
	"Paradise."	"Crab."	"Paradise."	"Crab."
Grenadier	19	36	36	76
Gladstone	8	56	21	57
James Grieve ..	23	41	37	50
Average for 48 trees	14	47	31	61

This is as striking a demonstration of the difference in variability of trees on "Paradise" and "Crab" as we have yet obtained in our crop records, or any other observations.

At the writers' request Dr. R. C. Knight studied the records from a statistical standpoint. It was found that if it were desired to detect a significant difference of 10 per cent. in the incidence of "scorch" upon two units of trees, the number of trees necessary in each unit to give us a reliable result would be 15 if the trees were on "Paradise" stocks and 420 if on "Crab." It is recognised that the number of observations is dangerously small for statistical generalisations, but the vast difference in the figures thus revealed cannot be neglected and is clearly of first importance to those engaged in fruit tree research.

It is also interesting to note in passing, that the variability on both "Crab" and "Paradise," is very much greater in this case where the personal factor of pruning is introduced.

Finally it should be made quite clear that in drawing this comparison between "Paradise" and "Crab," we are *not* referring to the whole class of Layered Stocks as "Paradise," but merely to the types identified upon this particular pruning plot. Observations on other plots appear to reveal many types of Layered Stocks which do not show this characteristic of increasing the susceptibility of the scion to Leaf Scorch.

At the present time we are not prepared to put forward any final explanation of these phenomena. The fact that we have grouped together as "semi-dwarfing" those stocks which we now associate with "Scorch" might suggest a direct correlation between size of tree and "Scorch." It seems hardly possible to hold this view, since the trees on the very dwarfing Metz Stock (Type IX.) show as yet practically no "scorching," also because, amongst the very variable pruning plot trees on "crab" stock there seems no obvious correlation between "Scorch" and size of tree. In the case of the "Paradise" root-stocks, with which we especially associate "Scorch," namely Types V., VII., and II., we are

tempted to point to the type of root system as shedding some light upon the subject. We have always grouped together these root-stocks, the main characteristic of which has been long coarse laterals devoid of fibre. In the case of Type V., the somewhat prolific adventitious rooting around the " collar " does not extend to the laterals.

The fact that scorch frequently manifests itself on trees upon these root-systems is not necessarily a condemnation of the stock, thought it certainly suggests that caution must be observed in the general use and treatment of such trees. Under our particular soil conditions we should certainly prefer to eliminate the Type V. stock as being the most susceptible, until we find ourselves able to control the trouble completely through nutritional or other methods ; but at present the Type II. stock fills a unique position, from which its tendency to " scorch " cannot, in our opinion, displace it.

It is most unfortunate that this valuable Doucin Stock (Type II.) is apparently being very rapidly superceded in certain continental areas by the much more easily propagated Type V., which goes under the misnomer of Doucin Amelioré (" Improved " Doucin !).

Varietal Susceptibility.

The trees used in our pruning experiments, already mentioned, have provided material for observations on the susceptibility of different varieties to leaf scorch. It is interesting to note that here again the trees showed little or no signs of the trouble for at least four years after planting.

It would appear, then, that the " scorch " does not, in our conditions, become serious until the trees have reached a certain stage in their development. Moreover, it has tended to become accentuated year by year as the trees have come into bearing.

The remarks already made on the influence of root-stock fully emphasise that the susceptibility of a variety may be altered by this factor, so that, in order to get an entirely satisfactory comparison, the varieties would require to be worked on a uniform layered stock. As a matter of fact, fortune seems to have favoured us to a considerable extent in that the types of " paradise " used for these commercial trees were not only less mixed than we at one time feared, but belonged almost entirely to the " semi-dwarfing " group. Wherever it has become possible to compare the effects of different known root-stocks on these trees, those on Type V. have invariably proved to be the most severely " scorched."

It has been possible to check our results on four varieties by comparing duplicate sets of trees on " Paradise " and " Crab " ; Table V. when analysed shows that these varieties retain precisely the same order of susceptibility in each case. This has encouraged us to present the full list in detail, partly to

provide some guidance to planters and tree raisers, and partly to invite criticism and information.

TABLE VIII.

Showing Order of Susceptibility under our Conditions.

Variety.	Class of Root stock.	Number and type identified.	Estimated per cent. of leaves "scorched."
Grenadier	"Paradise"	One Type II.	72
Lord Derby ..	,,	6 type V.	69
Gladstone	,,	9 type V.	65
James Grieve.. ..	,,	13 type V., 1 type II.	61
Beauty of Bath ..	,,	3 type V., 2 type III., 1 type II.	60
Allington	,,	1 type V.	58
Cox O.P.	,,	4 type II., 2 type III.	56
Rival	,,	2 type II.	49
Newton Wonder ..	,,	16 type II.	43
Grenadier	"Crab"	(Seedlings)	36
Early Victoria ..	,,	,,	35
Gladstone	,,	,,	32
James Grieve.. ..	,,	,,	25
Lane's Prince Albert	,,	,,	19
Worcester Pearmain ..	"Paradise"	1 type II.	16
,, ,, ..	"Crab"	(Seedlings)	2.5

Each of these percentage figures is based on thirty-two trees.

It is perhaps worth stating how these estimates were arrived at. The writers of this paper carefully examined each tree in turn and accorded each a mark from 0 to 10; from time to time the estimates were checked by actual counts of the leaves on individual branches. No attempt was made to allow for the degree of "scorching"; and with two varieties, Lord Derby and James Grieve, the estimate was somewhat complicated by unhealthy foliage due apparently to other causes. Thus the order might under other conditions be somewhat modified.

Unfortunately time did not allow the completion of the task. Four sets of trees were thus omitted from careful individual records. It was, however, noted that the Early Victoria trees on "Paradise" were almost all badly "scorched," as were the trees of Annie Elizabeth on "Paradise"; those of Bismarck on "Crab" were moderately "scorched"; whilst those of Norfolk Beauty on "Paradise" were as little "scorched" as any variety in the plot.

RELATIONSHIP BETWEEN PRUNING AND LEAF SCORCH.

Perhaps the most interesting of our observations on the Leaf Scorch of the pruning plot is the apparent amelioration of "scorch" as the result of certain methods of pruning. Reference will be made later to the possibility that this is not a direct result of pruning, but may be brought about by the interference of pruning with the activities of the trees as represented by cropping.

Ever since 1919 it has been noticed that the " scorch " has appeared later and less severely on the trees which are subjected to leader tipping and spur pruning.

The figures already presented, when further analysed from the point of view of pruning, give the results shown in Table IX.

TABLE IX.

Showing Estimated Percentage of " Scorched " Leaves on Tipped and Untipped Trees.

Variety.	" Paradise."		" Crab."	
	Tipped.	Not Tipped.	Tipped.	Not Tipped.
Grenadier	55	89	14	58
Lord Derby ..	66	72	—	—
Gladstone	44	86	25	39
James Grieve ..	47	74	11	39
Allington	46	69	—	—
Cox's Orange Pippin ..	54	58	—	—
Rival	34	64	—	—
Lane's Prince Albert ..	—	—	9	29
Early Victoria ..	—	—	16	54
Worcester Pearmain ..	13	19	1	4
Beauty of Bath	64	57	—	—
Newton Wonder ..	43	42·5	—	—
Average	47	63	13	37

The outstanding features of this table are, first, that in all cases except the last two, the leader tipped trees were less " scorched " than those not leader tipped. (The two exceptions will be dealt with later.) Secondly, that the difference is relatively greater amongst the trees on " Crab " than amongst the same varieties on " Paradise." At first sight it seems difficult to explain this greater relative difference in the more vigorous trees on " Crab," where one would have expected the results of lack of pruning to be less obvious. This, however, coincides with a similar relative difference in cropping, and we must therefore look at our figures in the light of crop records.

RELATIONSHIP BETWEEN BLOSSOM, CROPPING AND LEAF SCORCH.

In reviewing our pruning results we were able to state that in nearly every case leader tipping delayed blossoming and cropping. There were, however, two partial exceptions : Newton Wonder, where in the early years the tipped trees cropped more heavily than those not tipped ; and Beauty of Bath, of which though none of the trees have cropped well, the tipped trees have regularly blossomed very freely. Curiously enough, it is these two varieties which provide the exceptions in Table IX. We have carried our investigations into this point

a step further in an attempt to correlate the Leaf Scorch mark with either number of blossom trusses, or subsequent set of fruit. For this purpose we have chosen Early Victoria as a variety showing the extreme of biennial bearing. Unfortunately we have only the data for this variety on very variable seedling stocks ; and the difficulty of directly correlating a heavy crop with the amount of leaf scorch lies in gauging what would be a relatively big effort for a tree of any particular size. We have included in Table X. the stem girth measurements of the trees, as being the most satisfactory available indication of their size and vigour. We have also included the crop figures for both 1923 and 1924, which indicate the " on " and " off " years of bearing, the former being presumably the trees' " big effort."

TABLE X.

Showing Relation between " Scorch " and Cropping on Untipped Trees of Early Victoria on " Crab."

Tree.	Girth of stem as indication of vigour.	No. of fruits, 1923.	No. of blossom trusses, 1924.	No. of fruits, 1924.	Estimated % of scorched leaves, 1924.
A1 ..	33 cm.	45	1939	1533	60
A2 ..	26 ,,	8	1726	618	100
A3 ..	34 ,,	11	3629	1743	80
A4	18 ,,	9	1022	260	70
A5 ..	18 ,,	9	1055	239	90
A6 ..	26 ,,	1	1997	860	90
A7 ..	21.5 ,,	213	78	95	30
A8 ..	39 ,,	577	46	311(?)	0
C1. ..	17 ,,	187	15	60	0
C2 ..	27 ,,	67	1408	822	80
C3 ..	32 ,,	209	522	643	80
C4 ..	29.5 ,,	287	22	42	20
C5 ..	32 ,,	9	1712	1275	90
C6 ..	28 ,,	491	8	32	Trace
C7 ..	30 ,,	1	1729	1185	70
C8 ..	40 ,,	14	1677	1790	0

There are here ten trees more or less badly " scorched " in 1924, and six slightly or not at all " scorched." Of the ten badly " scorched " trees every one cropped much more heavily in 1924 than in 1923, i.e., 1924 was their " on " year ; of the other six trees, five cropped more heavily in 1923 than 1924, i.e., 1924 was their " off " year.

This kind of evidence is apparent, if not always in so striking a degree, in the great majority of cases which we have analysed. Here and there exceptions like tree C8 in the table do occur ; if there is really a connection between the crop of blossom or fruit borne by the tree and its tendency to " scorch," as we

are inclined to believe, these exceptions may be capable of one of the following explanations. The mixture of root-stocks on this plot may be quite enough in itself to account for them ; for, under our conditions, certain of the named root-stocks, when worked with Bramley, Worcester, and Lane's, have up to the present shown no " scorch " at all.

Further, it has been noticed on this plot, as well as on certain other plots, where observations have been made, that the headland trees are often less " scorched " than those in the interior of the plots ; tree C8 (Table X.) is the second tree from the headland. And again, although our soil is on the whole exceptionally uniform, it is impossible entirely to eliminate this factor.

Additional evidence which points to a correlation between blossoming or cropping and the tendency to " scorch " can be drawn from Table IX. Thus the two varieties on " Paradise " showing the greatest reduction in " scorching " from tipping, Gladstone and Rival, are precisely those two which have cropped most lightly on the tipped trees. Again, it has already been pointed out that the reduction of " scorching " on the tipped trees is greater amongst those worked on " Crab " than among the same varieties on " Paradise." This phenomenon can be explained on the same hypothesis, since the reduction of cropping due to tipping is relatively much greater amongst the trees on " Crab " than amongst those on " Paradise."

One more bit of evidence, which seems to favour this idea, that it is cropping rather than pruning which influences the amount of " scorch " is the observation made that the unpruned trees of Lane's Prince Albert on known stocks, which were in their " off " year, showed less " scorching " than the duplicate pruned set, most of which were yielding their first considerable crop.

If one takes into account the nutritional aspect of leaf scorch, and the potash factor recently brought to light by Mr. Wallace, of Long Ashton, the high percentage of potash shown by most analyses of the ash of apples is extremely significant.* Gourley, in his *Textbook of Pomology*, states that : " The ash of apples averages over one-half of potash, not unlike the other fruits ; however, the analysis shows rather more variation for ash than has usually been noticed in the fruits in general." A rather similar statement is made by Gardner, Bradford and Hooker in *Fundamentals of Fruit Production*.

A factor in the behaviour of leaf scorched trees as yet unexplained, namely the uneven distribution of " scorch " amongst the individual branches of particular trees has shed a sidelight upon a different aspect of the reaction between " scorch " and yield of fruit. The fruit from " scorched " and " non-scorched " branches of certain trees of Newton Wonder and Allington Pippin was picked and recorded separately ; in every case that from the

* Annual Reports Agric. and Hort. Research Station, Long Ashton, 1921, 1922, 1923.

" non-scorched " branches was materially larger than the rest, the difference being sometimes as much as fifty per cent.

COMMERCIAL METHODS OF MANURING AND LEAF SCORCH.

The writers of this article have made no attempt to go fundamentally into the problem of nutrition in its relation to Leaf Scorch. The work of Mr. Wallace along this line has already been referred to, and has doubtless been followed with keen interest by readers of this *Journal.*

Our observations here are in the nature of a criticism of a field practice, typical of certain districts, and appear worth recording from that point of view.

Some growers have been apt to attribute leaf scorch to general starvation, and they have been disappointed, like ourselves, when they have failed to eliminate the trouble after repeated dressings of organic manures. Our pruning plot, which we have already shown to be suffering severely from Leaf Scorch, has been given what would ordinarily be called " generous " treatment. The following is the chronicle of its dressings since 1919.

1919.	15 tons London Dung per acre.
	10 cwt. Potash Flue Dust per acre.
1920.	30 cwt. 8% Black Shoddy per acre.
	10 cwt. Best Ground Lime per acre.
1921.	15 tons London Dung per acre.
	4 cwt. Bone Siftings per acre.
1922.	15 tons London Dung per acre.
1923.	30 cwt. 7%—8% Black Shoddy per acre.
	4 cwt. Sulphate of Potash per acre.
	(applied to half the trees of each variety).
1924.	12 cwt. Meat and Bone Meal per acre (in two dressings).
	4 cwt. Peruvian Guano per acre (summer dressing).

It will be seen that the dressings have been up to the present predominantly nitrogenous. In the light of Mr. Wallace's work it would appear that many of these dressings have been worse than useless, since by their very nature and persistence they have only tended to destroy the balance between the various constituents of plant food.

On the other hand, under our soil conditions, complete starvation does appear, at any rate, in the early stages, to accentuate the trouble. The number of " scorched " leaves has been recorded upon duplicated plots of trees on known stocks, some of which have received nothing but the annual ploughing in of a non-leguminous green crop, whilst others have been manured similarly to our pruning plot. The figures speak for themselves.

TABLE XI.

Showing the Average Number of "Scorched" Leaves per Tree.
(8 or 16 trees in each group.)

	Manured. (Plot XIII.)	Unmanured. (Plot XIV.)
Worcester Pearmain on Type I. ..	12.5	34.0
" " " V. ..	44.7	81.0
Bramley's Seedling on Type I. ..	38.9	51.7
" " " V. ..	82.0	117.3

The nutritional question must then be fully considered in all methods of amelioration in the field.

Since this side of the question is obviously so important, we give below a typical chemical analysis of our soil made in 1913 by the late Mr. L. E. Holyman, of the South Eastern Agricultural College, Wye.

TABLE XII.

Typical Chemical Analysis of Soil at East Malling.

	Soil.	Subsoil.
Moisture	1.067	1.066
Organic Matter	3.386	2.033
Nitrogen	.1047	.1400
Carbonate ($CaCO_3$)	.354	.352
Potash (K_2O)	.2951	.316
" available	.024	
Phosphoric Acid (P_2O_5)	.1117	.073
" available	.0296	

Our observations upon root-stock, pruning, and cropping all seem from the Pomologists' standpoint to indicate certain disturbances in the "balance" of the tree, the restoration of which can only be accomplished as the Physiologist and Chemist define that "balance." It is to be hoped that these observations may contribute something from the field aspect.

SUMMARY.

Observations upon Apple Leaf Scorch in the field have shown :—

1. The variety of root-stock strongly influences the development of leaf scorch.

   (*a*) Amongst the layered stocks, three varieties, all classed as "semi-dwarfing," are notable for their tendency to increase the "scorch."

   (*b*) Amongst the seedling "crab" or "free" stocks there is very great variability; but when compared, on the average, with two

of the above-mentioned "semi-dwarfing" varieties, they show distinctly less tendency in this direction.

(*c*) These manifestations of varying susceptibility to "scorch" have been noted on the unworked stocks themselves, and on very different types of soil.

2. Different varieties consistently show different degrees of susceptibility to Leaf Scorch. The order of susceptibility of the only four varieties available for comparison proved to be identical on layered and seedling roots.

3. The practice known in pruning as "leader tipping" has consistently tended to reduce the "scorch."

4. There appears to be a direct relationship between blossoming and fruiting, on the one hand, and Leaf Scorch on the other. This may account for the effect of leader tipping noted above.

5. The Leaf Scorch appears directly to reduce the size of the fruit.

6. Whilst on young trees lack of organic manures has tended to accentuate the "scorch," on older trees generous feeding with organic (predominantly nitrogenous) manures has by no means checked the trouble.

BLACK CURRANT VARIETY TRIALS :*

Reliability of Results.

THE VARIABILITY IN CROPPING OF INDIVIDUAL BLACK CURRANT BUSHES AS A GUIDE TO THE SUITABLE SIZE OF EXPERIMENTAL PLOTS.

By R. G. HATTON, N. H. GRUBB and R. C. KNIGHT.

Planning Field Trials: General Considerations.

When we planned our first series of black currant variety and manurial trials, although we realised that our material was certain to show some variation, we had no idea how great a variation to expect, since individual bush records had seldom, if ever, been kept by earlier workers. Hence we had no basis for calculating the optimum size for our experimental plots.

The problem of the optimum size of plots arises from the variability of individual bushes of the same variety. This variability persists in almost all biological experiments, even under the most carefully controlled conditions. It will be obvious that, under field conditions, its elimination will be still more difficult. We are therefore in search of the minimum number of individuals which will give an average, or "mean," crop weight figure truly representing the characteristics of the variety, and not seriously distorted by chance extremes.

At the outset of our black currant experiments we used the customary method of group records from each plot, and, although the plots in any one of our experiments were of uniform size, they have varied in different experiments from units of 8 bushes to 112. We had no means of telling which of these extremes was likely to be nearer to the minimum required for reliability.

Questionable Value of Group Records.

Close observations soon forced upon us the conclusion that such group records were of questionable value. For instance, in our original manurial trials with black currants, about the fifth or sixth year the whole method became complicated by the appearance of varying attacks of both big bud and "reversion." Since both these troubles are known to affect the cropping of the bushes, we felt obliged to draw a line somewhere, and leave out of our group records the worst affected bushes. We thus came face to face with a very

* Reprinted from *The Journal of Pomology and Horticultural Science*, Vol. IV, Parts 3 and 4.

serious cause of individual variability, and soon found ourselves forced to record the bushes individually.

Even apart from this question of disease, it was obvious that quite local conditions, of soil, site or cultivation, materially affected the uniformity of the results. For instance, we soon observed that proximity to a hedge or poplar wind-break adversely affected the growth and cropping of the bushes. Again, as in the case of top fruit plantations, headland bushes were frequently noticed to be the best.

Individual Bush Records.

Therefore, in 1920, we laid down new manurial and variety trials, upon which it was decided to keep individual bush records of cropping and the incidence of disease. These records have now been accumulated for four years, and enable us to draw tentative conclusions as to the actual variability to be expected, and therefore the best sizes for experimental plots.

For our present purpose the second series of variety trials mentioned above will be here discussed.

The plots consisted of 73 bushes of each of the five chief varieties, propagated from bushes which for some years had been under close observation at East Malling. The records here analysed are based on from 60 to 70 bushes of each variety, the remainder having had to be discarded owing partly to " reversion," and partly to the need for reserving a few bushes for other experimental purposes.

Control of Field Conditions.

The bushes under review were planted on ground that had been cropped and manured uniformly for seven years ; the site itself was chosen for the apparent evenness of the soil. The bushes were all yearlings when planted, and were all cut to near ground level at the same time, soon after planting. In all respects the subsequent treatment has been as uniform as possible ; the pruning (to which we shall have cause to refer again below, as an element in the variability) has always been on the light side, and has been done throughout by members of the Staff who realised the importance of uniform treatment. The whole object in view was to secure as accurate comparative crop weights as possible, since the whole plantation constituted our main variety trial. It should, perhaps, be stated that, owing to limited space, these bushes had to be interplanted between young apple trees, of very variable size, at 15 feet apart. This may have added somewhat to the variability of the bushes. Each of the five varieties under comparison was in an unduplicated row, 15 feet from its neighbour, and 360 feet in length.

RECORDS HERE PRESENTED.

The first crop was picked in 1921, but the amount was then naturally so small that the records for that year are not particularly stressed in the statistical analysis; they are, however, presented in order to show certain interesting points in the early cropping of the varieties.

It does not appear to us necessary to present here the twenty complete sets (five varieties each for four years) of individual bush records, since, as subsequent tables will show, the "probable errors" for the different varieties and seasons are not strikingly different. But for purposes of our own references in this paper, and in the hope that some statistician may be tempted to analyse these figures on his own account, we present as an appendix the complete data for the variety French, and in graph form similar data for Baldwin. These two have consistently differed more widely in cropping than any other pair of varieties.

NECESSITY FOR CRITICAL EXAMINATION OF RECORDS.

These individual bush records of Baldwin and French themselves afford an excellent example of the variability we are studying. Even if, taking either variety by itself, we work out the average crop weights for each adjacent group of six bushes of that variety, we still find, from group to group, differences as wide as frequently occur between distinct varieties. The fact that there exists such wide variation within a single variety often results in the overlapping of group averages of varieties actually very different. Examine, for instance, the average crop weights for adjacent groups of 6 bushes of the varieties French (Merveille de la Gironde) and Baldwin. (See Table I.)

TABLE I.

Average Crop Weights for Adjacent Groups of 6 Bushes.

	Year 1923.		Year 1924.	
	French.	Baldwin.	French.	Baldwin.
Group.	oz.	oz.	oz.	oz.
1	22.0	69.3	82.8	104.8
2	28.5	51.7	103.3	104.0
3	20.2	68.8	91.0	114.5
4	23.5	52.8	83.0	92.3
5	19.8	49.3	88.3	87.5
6	23.0	58.7	85.5	94.2
7	19.5	65.0	94.5	104.7
8	20.5	48.5	88.0	93.0
9	15.8	50.0	86.0	106.2
10	15.0	58.8	82.0	108.5
11	18.0	64.2	—	102.0
12	—	50.3	—	—

From this Table it will be seen that, whilst in 1923 even the extremes of the two varieties came nowhere near overlapping, in 1924, five French groups (Nos. 2, 3, 5, 7 and 8) were all higher than the lowest group of Baldwin (No. 5), and five groups of Baldwin (Nos. 4, 5, 6, 8 and 11) were lower than the highest group of French (No. 2). This happened in spite of the fact that the averages for the whole plots were widely enough separated in 1924 (as judged by the "probable error") to show a difference in favour of Baldwin extremely likely to be repeated in further trials. Since this can occur with strictly controlled material and varieties as widely different as any in our trial, we feel that we can no longer rely on the comparative results obtained from small plots.

Method of Examination—The Probable Error.

We must then adopt a size of plot sufficient to smooth out this variability, and to show how this may be done we propose to use the mathematical conception called the "probable error."

In order to explain what we mean by the "probable error" we propose to use some of our actual figures as examples; therefore Table 2, presenting the average crop weights per bush of five varieties for four years, with the "probable errors," is introduced at this point.

The "probable error" shows within what limits there is an even chance of the true cropping power lying, i.e., it gives a measure of the limits within which the results from similar trials are likely to vary. For example, it will be seen in Table 2 that the variety Seabrooks cropped in 1922, 14.1 ozs. per bush; the figure $\pm .27$ which follows is the probable error, and shows that there is an even chance of the true cropping power lying between $14.1 - .27$ and $14.1 + .27$, i.e., between 13.83 and 14.37. In other words, if the experiment were repeated 100 times under similar conditions, the crop figure would lie between these limits (13.83 and 14.37) fifty times, and outside them fifty times. The size of this probable error, as will be shown later, is ruled very largely by the number of individuals in the plot.

What Differences are Significant?

What we are aiming at is to be sure that the differences shown by our experimental results are significant, i.e., that a repetition of the experiment under similar conditions would be likely to give a similar result. For instance, to take a further example from Table 2, if the average crop weights of Goliath and Boskoop in 1922 are compared without reference to the probable error, it would appear that in that year Goliath bore a somewhat heavier crop, which, when worked out on an acreage basis, represents a difference of $42\frac{1}{2}$ lbs. per acre, on a total crop of about 1,200 lbs. (bushes only two years old). However, when the probable errors are taken into account, it will be seen that there is a

TABLE II.

Average Weight of Crop per Bush (ounces). With Probable Errors.

	No. of Bushes.	1921.	No. of Bushes.	1922.	No. of Bushes.	1923.	No. of Bushes.	1924.	No. of Bushes.	1922, 1923, and 1924 together, calculated independently.
French ..	70	2.85±.36	67	16.1±.32	66	20.5±.54	61	88.2±1.21	61	124.6±1.66
Seabrooks ..	70	3.92±.46	70	14.1±.27	67	25.7±.50	62	91.1±1.17	62	130.8±1.43
Boskoop ..	70	1.26±.21	70	15.9±.35	68	23.6±.38	67	108.1±1.60	67	147.4±1.92
Goliath ..	70	1.07±.27	70	16.5±.41	70	35.0±.89	66	96.6±1.69	66	147.5±2.46
Baldwin ..	71	6.0 ±.57	73	29.9±.65	73	57.1±1.28	70	99.6±1.68	70	186.2±2.56

considerable chance that the respective ranges within which the true cropping powers lie may overlap, and that in 1922 the apparent differences in cropping may have been due to chance. Thus it is impossible from these figures to decide which variety possesses the greater cropping power, owing to the difference between them not being truly significant. On the other hand, if we refer again to Table II. we can see at once how significant is the superior cropping in 1922 and 1923 of Baldwin over any other variety.

Relationship between Experimental Difference and Probable Error.

Where the experimental difference (i.e., the difference between two averages) is many times larger than the probable errors (as in the example just quoted, of Baldwin's crop in 1922 and 1923 compared with that of any other variety), it is obvious without further calculation that the result is significant, the chances of overlapping being in such a case very small. But where the experimental difference and the probable errors are not so widely separated, it is necessary to decide upon some criterion by which to judge the significance of the result; or, in other words, to decide how many times the experimental difference must be larger than the probable error before we can regard the result with confidence. Fortunately for non-mathematicians like ourselves, calculations have been made which give us, for any particular relationship between the experimental difference and the probable error, the number of chances there would be in favour of our obtaining a similar result on repetition of the experiment, or, in other words, how frequently we could expect to get a result in the same direction.

Therefore, we have to ask ourselves what number of chances is good enough; and in answering this question we must remind ourselves that experimenters should not take undue risks. One of the calculations referred to above shows that, if the experimental difference is 3.2 times its probable error, there are thirty chances to one that the result is significant, or stated otherwise, that thirty-one repetitions of the experiment under similar conditions could be expected on the average to give a result in the same direction thirty times, and a contrary result once.

For instance, it we compare the average crop weights of Seabrook's and Boskoop in 1923, we find that the difference between these averages (i.e., the experimental difference, 2.1 oz.) is slightly over 3.3 times its own probable error (obtained by squaring the probable error of each average, adding the squares together, and taking the square root). If we repeated this experiment under similar conditions, with the same number of bushes, a large number of times, we could expect that, on the average, Seabrook's would crop better than Boskoop, as in this experiment, thirty out of each thirty-one times.

For the experiments under discussion here we consider that such a thirty to one chance should surely be good enough to indicate a real difference in the

direction shown, and we propose to use this severe test henceforth as the criterion of the significance of our results. That is to say, when the experimental difference is 3.2 times (or more) its probable error, we feel satisfied that this difference is a real difference of cropping power, and is not due to chance variation.

It seems to us probable that, if a single season's result can give us thirty chances to one in favour of its significance, the repetition of a similar result for several successive seasons can be regarded with still greater confidence, even though the same bushes are used throughout. Such repetitions are seen to occur frequently in Table II.

Examination of Records in Light of this Criterion.

Before proceeding to indicate the minimum size of plot demanded by this criterion, we propose to show what the value of our results would have been had we had various numbers of bushes from six to seventy.

An examination of the crop figures for Baldwin and French, given in the Graphs and Appendix, shows that in one year out of four (1923), single bush plots could almost have been relied on to give a significant result, though four out of seventy-three bushes of Baldwin actually gave a smaller crop than the best bush of French, and thirty-five out of sixty-six bushes of French yielded more than the poorest cropping bush of Baldwin.

We have already shown in Table I how the results with six bush Groups of French and Baldwin overlap in 1924 (though not in 1923) and we propose to seek an answer to our question by following up these lines of thought. Table III reproduces the 1923 portion of Table I with the probable errors included.

Table III.

Crop, in oz., of adjacent groups of 6 *bushes in* 1923 *with Probable Errors.*

Group.	French.	Baldwin.
1	22.0±1.35	69.3±8.70
2	28.5±1.76	51.7±4.37
3	20.2±1.17	68.8±2.94
4	23.5±1.65	52.8±2.00
5	19.8± .61	49.3±3.25
6	23.0±1.41	58.7±3.26
7	19.5±1.57	65.0±1.78
8	20.5±1.22	48.5±5.55
9	15.8±1.49	50.0±2.13
10	15.0±1.56	58.8±4.90
11	18.0±1.28	64.2±4.13
12	—	50.3±3.35

It will be readily seen that in 1923 there was a very small chance of any six bushes of Baldwin cropping as low as any six bushes of French. Thus the two seasons gave a totally different result with six bush units. It is of interest

therefore to see how many bushes would have been required in 1924 to give a truly significant result.

If the same bushes are taken in adjacent groups the crop figures for 1924 are as shown in the following tables of progressively larger groups.

TABLE IV.

1924 *Crop in ozs. of French and Baldwin in adjacent groups of* 6 *bushes with Probable Errors.*

Group.	French.	Baldwin.
1	82.8±4.95	104.8±7.12
2	103.3±3.59	104.0±6.98
3	91.0±2.31	114.5±4.26
4	83.0±3.23	92.3±2.81
5	88.3±2.66	87.5±7.27
6	85.5±3.29	94.2±9.78
7	94.5±2.73	104.7±2.88
8	88.0±5.28	93.0±4.13
9	86.0±3.66	106.2±4.31
10	82.0±4.33	108.5±3.81

Taking each parallel pair of groups we find that on the average the experimental difference is only 2.2 times its probable error, giving about seven chances to one in favour of a similar result on repetition.

If we had had only six bush plots and if in our selection of these six bushes we had been exceptionally fortunate, we might have happened to take pairs three, nine and ten and have obtained a result giving from 70 to 900 chances to one in favour of its significance, but in the remaining seven selections the chances in either direction would have been very slight.

Let us see from the following table what happens if we double the size of our groups.

TABLE V.

1924 *Crop in ozs. of French and Baldwin in adjacent groups of* 12 *bushes.*

Group.	French.	Baldwin.
1	93.0±3.56	104.4±4.75
2	87.0±2.06	103.4±3.30
3	86.9±2.05	90.8 ±5.86
4	91.2±2.90	98.8±2.67
5	84.3±2.72	107.3±2.76

Again taking each parallel pair of groups we find that on the average the experimental difference is 2.88 times its probable error and therefore the chances are rather higher—namely nineteen to one—in favour of obtaining a similar result on repetition. Here again in only two out of the five cases a fortunate choice of groups would have given us a more or less significant result.

Let us twice more double the size of our groups.

TABLE VI.

1924 *Crop in ozs. of French and Baldwin in adjacent groups of* 24 *and* 48 *bushes.*

24 Bushes.

Group.	French.	Baldwin.
1	90.0±2.05	103.9±2.83
2	89.1±1.76	94.8±3.20

48* Bushes.

Group.	French.	Baldwin.
1	89.5±1.35	99.4±2.15
2	86.9±1.24	96.1±1.96

On the average, in the case of the 24 bush groups, the experimental difference is 2.77 times its probable error, giving sixteen chances to one in favour of its significance. In the case of the 48 bush groups the experimental difference is 3.93 times its probable error. Here the chances are about 120 to one in favour. We have then, with forty-eight bushes, exceeded a size of plot which even in 1924 would have given us a significant result judged by our severe criterion. With the whole number of bushes in our comparative plots—sixty-six French and seventy Baldwin—the experimental difference was 5.51 times its probable error, giving an emphatically significant result with several thousand chances to one in its favour. Even in 1924 then, these plots were distinctly larger than was necessary. The fact that the result was in the same direction and even more significant in the two previous seasons must presumably greatly increase the chances in favour of repetition in a similar direction.

Regarding the figures from another point of view, we find that comparisons of parallel series of the six-bush groups give three significant differences from ten comparisons (i.e., 30 per cent.). The twelve-bush groups give two significant differences from five comparisons (40 per cent.). The twenty-four bush groups give one significant difference from two comparisons (50 per cent.), and the forty-eight bush groups both give significant differences (100 per cent.). This shows the expected increase in the number of significant results as larger groups are taken. We feel satisfied that if our complete records for the five varieties were subjected to a similar analysis, they would strengthen this line of argument.

Before leaving these figures we would like to point out that they afford an admirable illustration of the well-known fact that the size of the probable error is governed by the number of individuals. Take for instance the probable errors for the various sized groups of Baldwin expressed as percentages. The average for the six-bush groups is 5.62 per cent., for the twelve-bush groups

* In order to obtain more than 1 group of 48 bushes from our total row of 73 or less, the 48 adjacent healthy ones at each end of the same row have been taken for this calculation.

3.89 per cent., for the twenty-four bush groups 3.04 per cent., for the forty-eight-bush groups 2.10 per cent., and for the whole seventy bushes 1.69 per cent.

Having now shown the position in regard to the two most widely separated varieties, we can return to the figures set forth in Table II to see what proportion of our experimental results will stand the test we have decided to adopt, viz., a chance of at least thirty to one in favour (which requires, as will be remembered, that the experimental difference shall be not less than 3.2 times its probable error). Table VII below gives, for each of the possible comparisons that can be made in Table II, this relation between the experimental differences and their probable errors.

TABLE VII.

Showing Ratio between the Experimental Differences and their Probable Errors set forth in Table II.

		Seabrooks.	Boskoop.	Goliath.	Baldwin.
French ..	1921	↑ 1.83	← **3.81**	← **3.95**	↑ **4.67**
	1922	← **4.78**	← 0.42	↑ 0.77	↑ **19.06**
	1923	↑ **7.06**	↑ **4.69**	↑ **13.93**	↑ **26.35**
	1924	↑ 1.72	↑ **9.92**	↑ **4.04**	↑ **5.51**
	Average for 1922-23-24.	↑ 2.83	↑ **8.98**	↑ **7.70**	↑ **20.19**
Seabrooks ..	1921	—	← **5.26**	← **5.35**	↑ 2.84
	1922	—	↑ **4.07**	↑ **4.89**	↑ **22.44**
	1923	—	← **3.34**	↑ **9.06**	↑ **22.85**
	1924	—	↑ **8.58**	↑ 2.67	↑ **4.15**
	Average for 1922-23-24.	—	↑ **6.93**	↑ **5.85**	↑ **18.89**
Boskoop ..	1921	—	—	← 0.55	↑ **7.80**
	1922	—	—	↑ 1.11	↑ **18.97**
	1923	—	—	↑ **11.78**	↑ **25.09**
	1924	—	—	← **4.97**	← **3.68**
	Average for 1922-23-24.	—	—	↑ 0.032	↑ **12.13**
Goliath ..	1921	—	—	—	↑ **7.81**
	1922	—	—	—	↑ **17.45**
	1923	—	—	—	↑ **14.11**
	1924	—	—	—	↑ 1.26
	Average for 1922-23-24.	—	—	—	↑ **10.88**

↑ The arrow against each figure in the above Table points to the name of the variety (of the two compared) which cropped the heavier.

It will be seen that where the figures are shown in block type the comparison in question will stand the particular test which we are applying; the other figures will not. If we include the whole four years, and disregard for the moment

the average figure of 1922, 1923 and 1924 together, we find out of forty possible comparisons, thirty-one significant differences. Even if the first year of cropping (1921) be disregarded, twenty-four out of thirty comparisons stand our test.

Now, if we examine the average figures for 1922, 1923 and 1924 together,* we find that the proportion of significant results is higher, and that the chances in favour of the results are often greater than for individual years. This seems to fortify the point we made earlier in this paper as to the enhanced value of results accumulated over a series of years. But we are by no means confident that this is so, in view of the fact that these significant results over the three year period were obtained with the identical bushes throughout, and do not strictly constitute the average of three distinct experiments.

Even now we have not disposed of the question of the response of varieties to different seasonal conditions, as will be readily seen from Table VII. In several comparisons, contradictory results were obtained in different seasons. For example, take the comparisons of Boskoop with Goliath. In 1921 and 1922 we have insignificant results; and in 1923 and 1924 significant results but in opposite directions. Clearly the varieties responded differently to the different conditions obtaining in the seasons concerned. On the other hand, we are faced with a different problem in the comparison of Boskoop with Baldwin. For three successive years the difference in favour of Baldwin was very large and unquestionably significant; moreover similar large differences were shown for four years in the group records from our earlier series of trials. Yet, in spite of this cumulative evidence, the exceptional season of 1924 gave a significant result *in favour of Boskoop.*

These facts surely show that the experimenter must be extremely cautious in generalising from one or two seasons' results. From a strictly practical point of view, the obvious course is to consider the total crops over a series of years. Although we have shown the figures for the years 1922, 1923 and 1924, we are by no means prepared to indicate the minimum period from which it is justifiable to draw conclusions.

Final Deductions as to Sizes of Plots.

Before entering upon a discussion of the practical aspect of our variety trial results, we prefer to carry our theoretical considerations to their logical conclusion. It is apparent from Table VII that, in view of the widely divergent results of the comparisons, it would be at least unwise to dogmatise as to the exact minimum size of plot required in all cases. The proportion of significant

* These average figures, and those in Table II, are not obtained simply by adding the yearly totals together and averaging them, but by taking *the three year total crop of each individual bush* and working out the probable errors and ratios therefrom.

differences, and the degree of their significance, which appear when any of the other varieties are compared with Baldwin, suggest that for these comparisons our plots were extravagantly large. On the other hand, it is obvious that several of the comparisons of the other four varieties amongst themselves would have required even larger plots than those we used to detect a significant difference.

We have said that we will not regard any difference between group averages as significant unless that difference is at least 3.2 times its probable error, so that in planning such trials we must aim at attaining this standard. Now we obviously cannot control the crop differences which we are seeking to determine, but we can control to some extent the probable error, as we have previously indicated, by varying the number of bushes in our plot. It must therefore be our aim to use such a number of bushes as to reduce the probable error of our difference to a value equal to $\frac{1}{3.2}$ ($\frac{5}{16}$) of that difference.

At least two factors must be taken into consideration in coming to a decision as to the size for experimental plots.

(*a*) *The variability of the material to be used, and the amount of control over conditions that can be exercised by the grower or experimenter.*

It may be asked, does the probable error vary much from variety to variety and from season to season ? That there may be some slight difference between varieties is shown in Tables IV, V, and VI, comparing French and Baldwin. It is therefore necessary to present complete figures in order to see how far these differences extend. This is shown, in this particular case, by expressing the probable errors (from Table II) as percentages of the means (see Table 8).

TABLE VIII.

Probable Errors (from Table II) *expressed as percentages of the means.*

	1921.	1922.	1923.	1924.	1922-23-24 together.
French ..	12.6	1.98	2.63	1.37	1.33
Seabrooks ..	11.7	1.94	1.93	1.28	1.09
Boskoop ..	16.6	2.20	1.62	1.48	1.30
Goliath ..	25.4	2.46	2.54	1.75	1.67
Baldwin ..	9.5	2.18	2.25	1.69	1.37

That this difference between varieties is not after all so striking at once becomes apparent, though curiously, both our "whitish-budded" varieties—Goliath and Baldwin—show, in general, slightly higher probable errors than the "reddish-budded" varieties—French, Seabrooks and Boskoop.

But looking at the three years records of the most distinct varieties of black currant we know, we find that the actual probable error varies between 2.6 per cent. and 1.2 per cent. These three years comprise three very different

seasons, and the figures therefore indicate that climatic conditions do not profoundly affect the probable error. The variation is slight enough to lead us to expect that unknown black currant material (of true race) would show a not dissimilar probable error, provided the conditions were comparable. It seems therefore fair to say that we may in general look for a probable error round about 2 per cent., that is, with sixty to seventy bushes. We propose then to adopt this 2 per cent. as a generally applicable figure.

It should be noticed that there is often a distinct reduction in the size of the probable error as the bushes get older and come into full cropping. We are confident, however, that this is only likely to occur with bushes remaining healthy.

The importance of the control of conditions in other directions also will be obvious. Our results with pruned and unpruned bushes, which will be dealt with later (see page 214) show how serious even this consideration may be.

(*b*) *The probable amount of divergence between the groups to be compared.*

We are not suggesting that the experimenter must have prevision of his results ! But in initiating his trials he will almost certainly have some knowledge of the probable behaviour of his material as, for instance, whether he is likely to obtain small or large differences. Is he trying to detect differences in obviously closely allied varieties like French and Seabrooks, or is he about to compare those of very distinct characteristics ? At any rate, he must decide upon the extent of difference which it is worth while to show. This must, of course, to some extent be a matter of individual judgment. As far as the experimenter is concerned we have suggested that he should adopt a severe test, i.e., that the difference he should look for should be 3.2 times its probable error. Where the probable error of an average crop figure is round about 2 per cent. (as in our experiments), the probable error of a difference between two such averages will be nearly 3 per cent., and this indicates that the experimental difference, in order to be significant, must be about 10 per cent. The grower will approach the question from a different point of view ; what difference will make it worth his while to try a new variety or change his accustomed routine ? Will the 10 per cent of the experimenter satisfy him ? On an average crop of one ton per acre, this would give him an additional 2 cwt. per acre, which at 1924 prices would represent a gross increase of about £6 per acre. Where great additional expense is not involved, as in the selection of the most suitable variety, surely this would be worth while. At any rate for the sake of argument let us accept this difference as of sufficient extent. If we may assume that the probable error of the average of seventy bushes is 2 per cent. and that chances of thirty to one are good enough, then Table IX will show the number of bushes necessary to detect differences of given magnitude.

Table IX.

Number of Bushes required to ensure significance of given percentage differences (assuming 2 per cent. p.e. on 70 bushes and chances of thirty to one for significance).

Experimental Differences to be demonstrated. Per cent.	No. of Bushes required.
1	5,680
2	1,428
3	633
5	228
10	57
15	26
20	15
25	10
30	7
35	5
40	4
50	3
60	2
75	1

(Similar tables could be worked out on the basis of larger or smaller probable errors, and higher or lower chances in favour of the result.)*

This table can be used in two ways—given the assumed conditions it shows first how large a plot we must have to detect a given difference, for example to render significant the difference between Boskoop and Goliath in 1922 we should have required about 500 bushes of each ! Second, it shows what difference we can regard as significant if we have a fixed number of bushes. For instance, in dealing with twenty-five bush plots, which are commonly being used for variety trials, it is inadvisable to regard as significant any cropping difference less than 15 per cent.

That this table ought to be of some real value to experimenters with Black Currants we feel confident. At the same time we must point out that the 2 per cent. p.e. assumed as a basis is almost certainly lower than it would be under ordinary field conditions. On the other hand the odds of thirty to one are deliberately chosen on the high side, and it would perhaps be fair to balance a somewhat higher probable error against somewhat lower odds, and so claim for our Table a fairly wide application.

Taking into consideration the three lines of evidence afforded by our own bushes, it does seem possible under approximately similar conditions to suggest a fairly definite and satisfactory number of bushes for general purposes.

We have first the fact that our full plots of from sixty to seventy bushes have frequently given us a margin beyond the safety line ; then it was shown

* For details of this method of treatment see the Journal of the Board of Agriculture, Supplement No.7, November, 1911, "The interpretation of the results of Agricultural Experiments." H.M. Stationery Office.

that, even in the most exceptional year 1924, as we approached groups of fifty bushes we also approached significance ; and now we have Table 9 definitely indicating about fifty-seven bushes as the number required under our conditions to show a significant difference of 10 per cent.

Now we have always emphasised the fact that many of these field trials, such for instance as manurial tests conducted on our land, can at most give general indications and elementary principles, and that each grower must try these out under his own conditions.

We feel that for these general purposes, under ordinary field conditions, we cannot recommend a unit of less than fifty bushes. In coming to such a conclusion we have to face the fact that some of our own trials with smaller numbers of bushes will be of assured value only when they have been repeated. In the absence of the data which we here present, we ourselves made the now obvious mistake, in designing our variety and strain trials, of using large units of bushes for most distinct varieties, and small units for our " sub-types " ! (In the case of our sub-types of Baldwin this mistake has already been remedied with plots of ninety-seven bushes.)

Subsidiary Factors in Bush Variability.

We now come to an interesting point with regard to the effect of pruning on the variability of the bushes. We happen to have two rows of a single variety from the same source, grown under similar conditions, with the exception that, while one is entirely unpruned, the other received normal commercial pruning. The crop figures for three years are shown in Table 10.

Table X.

Cropping in ozs. per bush of Baldwin, pruned and unpruned.

	Pruned.	Unpruned.
1922.	4.5± .37=8.26%	5.9± .32=5.41%
1923.	19.9±1.18=5.94%	44.7±1.67=3.73%
1924.	81.2±3.57=4.39%	92.7±2.34=2.52%

Though more than one operator had a share in the pruning of these bushes, it was done under the instruction of one individual, and with the avowed object of taking a similar proportion of wood from each bush. Our purpose here is merely to show that the pruning has considerably increased the probable error. We do not propose to deal in this paper with the reduction of crop from its economic aspect.

We have made some attempt to follow out the behaviour of the individual bushes from year to year, with a view to discovering any tendency towards persistent high or persistent low cropping. Graphs have been prepared of the cropping of four varieties over three years ; amongst all these 280 bushes, less than 8 per cent. have shown any tendency towards persistent high cropping,

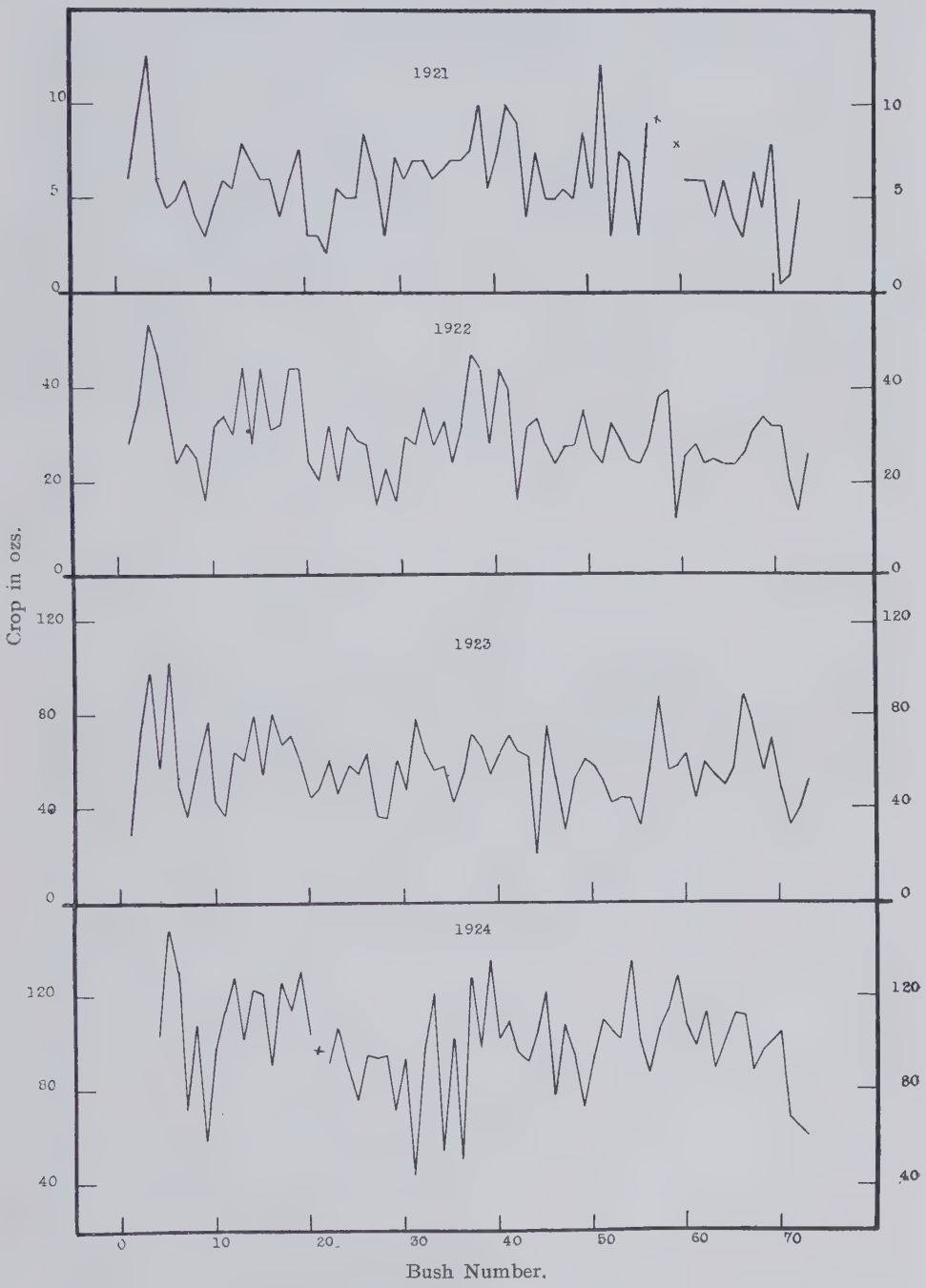


FIG. VII.

Diagram showing cropping on individual bushes of Baldwin.

and about 8 per cent. have shown a similar tendency towards low cropping. The great majority of those bushes that have varied considerably from the average have shown an upward tendency in one year and a downward tendency in another.

These graphs (Fig. VII) illustrating the annual performance of individual bushes of Baldwin, are fairly typical of all the varieties. A general view would seem to suggest that differences of location would account for a good many of the extreme variations. But there remain enough cases of alternate high and low yields from individual bushes to suggest the possibility of a tendency to biennial bearing. This hypothesis receives some support from the last column of Table VIII. It will be observed that, when the crops for 1922, 1923 and 1924 from the individual bushes are added up separately, there is a pronounced reduction in the probable error (expressed as a per cent.), which presumably implies a smoothing out of the variability. So far as we are aware this is the first instance in which such a tendency in small fruits has been pointed out.

The Economic Interpretation of the Figures.

What then is the value of these figures to the grower, and their interpretation as a guide to the cropping powers of the varieties? We have already said that an increase of 10 per cent. on a crop of 1 ton per acre of black currants would even in 1924 have brought in an increased gross return of £6 per acre. Consider now the meaning of the average figures in Table II, and the complement, showing their significance, in Table VII. The outstanding feature of these trials is the comparison of Baldwin with any other variety; out of sixteen possible comparisons twelve, according to our severe test, show a significant difference (though not necessarily to the exact extent shown) in favour of Baldwin, and in three of the other four cases Baldwin actually gave a heavier crop, leaving but one comparison unfavourable to Baldwin, and this in the exceptional year 1924. Now let us go on to see how much superior was its cropping power, and the increased economic return thereby produced.

Table XI shows the figures in the last column of Table II worked out on the basis of cwts. per acre per year.

Table XI.

Average Crop per acre per year, 1922, 1923, and 1924 together.

	cwts.
French	27.8
Seabrooks	29.2
Boskoop	32.9
Goliath	32.9
Baldwin	41.6

This superiority of Baldwin under our conditions would have given a gross increase over any other variety of not £6 per acre, but, at the 1924 price (the lowest of recent years), £26 per acre per annum.* Nor is this all. Not only could the Baldwin bushes have been planted much closer than those of other varieties on account of their comparatively dwarf growth (our figures are based on a distance of 5 ft. by 7 ft. 6 ins. for all varieties), but we have invariably been able to get a higher price for the fruit of Baldwin than for that of any other variety (sometimes double the price made by the fruit of Boskoop) largely owing to its lateness. Further, the yield of Baldwin was proportionately higher in the early years than later, giving a more prompt return on investment.

This point of early return, as shown by the figures in the 1921 and 1922 columns of Table II, is of more importance than is often realised. When we first examined these figures, we were inclined to think that they were (except in the case of Baldwin) largely a matter of chance. But they so strikingly confirm the results of our earlier series of variety trials that we consider the whole point worth discussing at some length.

In each trial, the crop of Boskoop and Goliath, in the first year or two, was markedly lower than that of French, Seabrooks, or of course Baldwin. In each trial, also, as the bushes developed the crops of Boskoop and Goliath overtook and passed those of French and Seabrooks.

This delayed cropping agrees so well with the known habit of the varieties Boskoop and Goliath—strong growth, especially in the early years—that we are inclined to think it is characteristic of the varieties, in the same way as certain strong growing varieties of apple, such as Bramley, are characterised by slow cropping. If such a behaviour can be traced in particular varieties of small fruits, it may be of considerable economic importance, since small fruits are so often planted with the object of getting quick returns. For instance, we find Baldwin, in the second year from the planting of one year rooted cuttings, cropping at the rate of 4 cwt. per acre, and a year later 1 ton per acre, compared with, say, Boskoop, which yielded less than 1 cwt. and nearly 11 cwts. per acre in the same years.

Regarded from the point of view of early return on capital, this fact adds greatly to the already superior value of Baldwin in our conditions.

In our earlier attempt to allow for this factor (Annual Report, East Malling Research Station, 1922), we took the crop of Baldwin as 100 in each year and the others in proportion. It is now clear that this seriously overweights the value of the earlier crops.

* Although Table VII shows these differences to be significant, and the cropping power of Baldwin in 1922, 23 and 24 to have been greatly superior to that of other varieties, it must not be thought that one could expect to obtain an identical difference on repetition of the experiment under similar conditions. Table VII merely indicates that we could expect a considerable difference in the same direction.

We propose instead the following basis. We deduct each year, from the gross value of the crop, a rough estimate of expenses, including: interest on investment £1 10s., rent £4, other expenses, year of planting and first cropping year £20, second cropping year £30, later years £40 per acre. Although these figures may be criticised as too high or too low, we must point out that the actual figures do not affect the principle involved, and are chosen without very accurate verifications, merely to illustrate the point.

Taking these estimates, and the value of the crop, as before at £60 per ton, we get the figures in Table XII.

TABLE XII.

Net return in £'s per acre after deducting rough estimate of expenditure *

Cropping year:	1st. 1921.	2nd 1922.	3rd 1923.	4th 1924.	Net profit per year from planting.
French ..	£19 6s. *loss.*	£3 6s. *loss.*	£4 10s. *loss.*	£130 18s. *profit.*	£15 13s.
Seabrooks	£17 13s. *loss.*	£7 6s. *loss.*	£5 18s. *profit.*	£136 14s. *profit.*	£18 9s.
Boskoop ..	£23 0s. *loss.*	£3 14s. *loss.*	£1 14s. *profit.*	£170 14s. *profit.*	£24 2s.
Goliath ..	£23 7s. *loss.*	£2 10s. *loss.*	£24 10s. *profit.*	£147 18s. *profit.*	£24 4s.
Baldwin ..	£13 10s. *loss.*	£24 6s. *profit.*	£88 14s. *profit.*	£153 18s. *profit.*	£45 12s.

We would only repeat that even these figures, which hardly need further discussion, make no allowance for the closer planting possible with Baldwin, or the higher price actually obtained for its fruit.

Finally, we ought to say that we have as yet no evidence of a shorter profitable life on the part of Baldwin than of other varieties, provided the bushes are given reasonable care.

In conclusion we wish it to be understood that by dwelling upon the superior performance of Baldwin under our conditions we are not intending to give it an unqualified testimonial. Our real object is to emphasise the supreme economic importance of varietal characteristics under any given conditions, and the absolute necessity for the repetition of such trials under conditions differing from our own, yet with at least as great a measure of control.

SUMMARY.

1. Individual bush records from plots of sixty to seventy bushes of five varieties of black currants show that, apart from the first cropping year, the probable error of the average crop of a variety in each year is approximately 2 per cent.

2. Of forty possible comparisons between pairs of varieties, only thirty-one significant differences are revealed, even when each plot comprises sixty to

* We wish it to be understood that we are not putting these figures forward as an indication of the possible profits to be made from black currants. They are merely presented as a *measure of relative value.*

seventy bushes. Smaller plots would have given correspondingly fewer significant differences.

3. The conditions which contribute to the variability of bushes are considered. These include seasonal differences and cultural practice. Pruning has materially increased the variability of cropping power among individual bushes in the same season.

4. From the results obtained, a table is deduced which shows the number of bushes required to detect a given difference, and conversely, what difference can be adjudged significant when the plots contain a given number of bushes.

5. Indications have been obtained that there may be a tendency towards biennial bearing in black currants.

6. The average crop figures for three years place the five varieties in the following order :—

Baldwin, 1.
Goliath, Boskoop, } 2.
Seabrooks, French, } 4.

7. The comparative economic value of the five varieties has been deduced from the records by applying ruling prices and arbitrary expense figures.

APPENDIX.

Crop Records of Individual Bushes of FRENCH.

Bush No.	1921.	1922.	1923.	1924.
	oz.	oz.	oz.	oz.
1	—	—	—	—
2	2½	19	14	54
3	1½	15	19	—
4	3	20	22	80
5	2½	20	25	97
6	1½	16	28	104
7	1	11	24	73
8	1	20	16	89
9	—	—	—	—
10	1	24	32	118
11	1½	24	31	104
12	1½	24	34	—
13	1	24	28	99
14	2	20	30	119
15	3	13	24	89
16	½	12	24	90
17	½	17	15	92
18	1½	—	—	—
19	3	13	15	90
20	1	13	23	88
21	4	18	20	106

Bush No.	1921.	1922.	1923.	1924.
	oz.	oz.	oz.	oz.
22	4	15	24	90
23	2½	17	30	80
24	4	12	16	85
25	1½	17	20	82
26	2½	15	19	80
27	1	13	32	104
28	2	15	18	79
29	2½	12	17	68
30	3	17	23	84
31	4	20	21	89
32	2½	9	21	72
33	2½	12	19	92
34	1	15	20	101
35	4	16	32	92
36	2½	5	—	—
37	3	16	20	90
38	2	24	23	98
39	4½	28	25	97
40	1½	12	18	75
41	2½	16	16	68
42	1	13	24	85
43	6	16	28	102
44	4	14	12	—
45	4	12	18	89
46	2½	8	19	85
47	3	15	18	111
48	4½	14	24	92
49	4	16	28	88
50	4½	18	18	96
51	3	16	17	80
52	6	17	18	88
53	3	12	—	—
54	4	16	24	114
55	5½	13	20	94
56	½	12	12	56
57	2½	12	10	96
58	3	5	—	—
59	4	16	12	74
60	4½	16	17	69
61	6	17	20	80
62	3½	14	20	96
63	4	16	16	101
64	4½	—	—	—
65	3½	17	12	104
66	3½	10	5	65
67	4½	17	17	66
68	2½	14	17	—
69	4½	15	15	92
70	—	17	16	77
71	—	20	28	—
72	4	24	16	92
73	2½	17	16	68

RASPBERRY VARIETIES AND THEIR CROPPING.

By N. H. GRUBB.

Records of the crops produced by raspberry varieties have been kept here since 1919. Although only some dozen or more varieties have been planted on such a scale and in such a manner as to satisfy the exacting requirements of modern variety trials (the bulk of the records have been kept on the original rows planted for "roguing" and for raising a supply of planting canes,) it seems worth while to present the records here as a rough guide to growers of the comparative value of the varieties in our conditions.

Since this annual report is now so much delayed, it is possible to include the figures for 1925. This gives the complete seven year records for eight varieties, all on 200 to 360 foot lengths of row; three year records for thirty-two varieties of which some twelve are in rows over 100 feet long; and two year records for forty-five varieties, in lengths of 50 feet or less. In addition, we have obtained the first crop from some twenty-four more varieties; but it is not considered worth while to present the figures here.

The eight varieties included in the seven year records have given average crops as shown in Table I.

TABLE I.

Average crop of eight varieties over seven years. Cwts. per acre.

1.	Pyne's Royal	23.9	Best every year except 1919.
2.	Devon	18.0	
3.	Bunyard's Profusion ..	17.2	
4.	Baumforth Seedling B. ..	16.6	Consistently held second place till 1924 and 1925 when severely injured by "anthracnose."
5.	Norwich Wonder.. ..	15.3	Cropped relatively well in 1923 and 1925.
6.	Hornet C.	13.7	
7.	Bath's Perfection ..	12.1	Cropped relatively well in 1919, never since.
8.	Superlative	9.0	Much dwarfed in our conditions.

Of the eight varieties, Pyne's Royal has cropped heavily every year, while Bath's Perfection (with the exception noted) and Superlative have been consistently poor. The other five have varied, and have all been good in some years and poor in others.

It is impossible here to give the complete records of all the varieties which have cropped for three years. Table II. gives the crop of each year separately, for all the varieties which on the average exceeded 1 ton per acre, with a few other varieties of interest. Where more than one sample of a variety is included in the trial, the best is given here.

Table II.

Cropping of Raspberries planted in 1921-22. Cwts. per acre.

		1923.	1924.	1925.	Average.
1.	Lloyd George	14.5	67.9	53.5	45.3
2.	Red Cross	12.0	44.6	43.9	33.5
3.	Helston	11.8	39.2	27.7	26.2
4.	Paradise Berry	8.0	46.8	23.5	26.1
5.	Laxton's Bountiful A ..	4.9	37.9	35.0	25.9
6.	Hornet A.	8.6	48.2	20.3	25.7
7.	Baumforth's Seedling A. ..	8.1	40.5	28.1 (die back bad)	24.9
8.	Pyne's Royal	10.7	33.6	29.6	24.6
9.	Reader's Perfection ..	4.9	38.5	29.1	24.2
10.	Black Antwerp A.	9.8	40.1	16.5	22.1
11.	Laxton's Bountiful B. ..	7.1	35.9	22.6	21.9
12.	Mitchells Seedling	6.4	37.5	18.5 (die back very bad)	20.8
	Semper Fidelis A. ..	7.4	34.4	20.6	20.8
14.	Red Magnum Bonum ..	13.2	30.1	17.7	20.3
	Baumforth Seedling B. ..	9.9	31.8	14.2 (anthracnose very bad)	18.6
	Priors Prolific	2.2	37.0	12.3 (die back very bad)	17.2
	Norwich Wonder ..	4.8	24.2	22.2	17.0
	Devon	5.7	22.9	20.6	16.4
	Red Antwerp A.	4.3	22.0	13.5 (die back very bad)	13.3
	Bath's Perfection	2.1	17.1	9.4	9.5

It will be seen that in total weight of fruit no other variety has come within a long distance of Lloyd George, except in the first year of cropping. Red Cross is also on the average well ahead of the rest of the varieties, although in 1923 it took third place, and in 1924 fourth. It is worth noting also, that of the five varieties included in both Tables I. and II., Pyne's Royal is again the leader. The other three varieties in Table I. were not replanted in 1922, and thus cannot be included in Table II. The cropping of the one-year older rows of these sorts, however, does not at all suggest that any of them would have been likely to crop as well as Pyne's Royal.

Of the forty-five varieties planted in the winter of 1922-23 very few are standard sorts. Small lots of one or two varieties included in Tables I. and II. were planted, but these do not provide a very satisfactory comparison. The bulk of the varieties were either sorts that have been more or less lost to cultivation, local varieties from various districts, or new sorts (many un-named) which are not yet widely distributed.

Table III. gives the two-year average crop of some of the more interesting of these sorts.

Table III.

Two-year average crop of varieties planted in 1922-23. Cwts. per acre.

		Cwts. per Acre.	
1.	North Ward	25.2	
2.	Winklers Seedling	25.0	
3.	Baumforth Seedling B.	24.3	
4.	" Chummies "	20.4	
5.	Norwich Wonder	19.9	
6.	Roosjes (from Holland)..	17.6	
7.	Storrie's Invincible (=Norwich W. ?)	15.9	
8.	Laxton's Prolific	15.7	
9.	Superlative ? (from Holland)	15.0	(much more vigorous than our Superlative).
10.	Red Antwerp F. (Barnet ?) ..	14.5	
11.	Wilder (from Holland)	14.3	
12.	Bath's Perfection ? (" Canadian Red ")	13.8	
13.	Hornet A.	13.5	
14.	Baumforth's Seedling A.	12.7	
15.	Brown Hague (from Holland) ..	12.2	
	Hornet E. (" Improved Hornet ") ..	9.5	(very late, part of crop lost).
	Red Antwerp E...	8.6	
	Filby Seedling (=Fastolf ?)	8.0	

Many of the unnamed seedlings cropped extremely well, four of them, in fact, better than any variety in the table. They are omitted because we do not yet know how far the phenomenon of " seedling vigour " is responsible for their early performance. We are quite prepared to find many of them falling off in cropping as they become more mature.

It may be of interest if we show how different samples of the same variety compared in their cropping. Table IV. gives these details for all varieties of which two or more samples were planted in 1921-22 or 1922-23.

The letters following the name of the county in Table IV. indicate definite growers or nurserymen ; samples noted as from Perthshire A. for example, all came from the same farm. It will be noticed that the best cropping samples of Hornet A, Black Antwerp A, and Baumforth B, all come from the same farm in Perthshire.

From the results shown in Table IV. we are strongly inclined to think that the same variety from different sources may have a considerably different value, at least for two or three years following planting. We hope to follow up this point in the near future.

It has already been pointed out that many of the results given in this paper are based on comparatively short lengths of row. A first attempt has now been made to find out what length of row is necessary to give a reliable trial.

TABLE IV.

Cropping of different samples of same variety. Cwts. per acre.

	Planted	Source	1923.	1924.	1925.	Average.
Hornet A.	21–22	Perthshire A.	8.6	48.2	20.3	25.7
,, ...	,,	Kent A1 ..	7.8	34.9	21.7	21.5
,, ...	,,	Cambridgeshire	5.9	34.6	18.5	19.7
,, ...	,,	Kent B. ..	5.7	30.5	19.0	18.4
,, ...	,,	Kent A. ..	5.2	28.9	16.9	17.0
,, ...	22–23	Holland ..	—	10.4	16.7	13.5
Black Antwerp A. ..	21–22	Perthshire A...	9.8	40.1	16.5	22.1
,, ,, ..	,,	,, B...	6.2	33.2	22.1	20.5
,, ,, ..	,,	,, C...	6.6	34.0	18.7	19.8
Baumforth Seedling B.'	21–22	Perthshire A...	9.9	31.8	14.2	18.6
,, ,,	,,	Kent A. ..	8.2	26.7	15.2	16.7
,, ,, ..	,,	Perthshire C.	9.7	30.2	10.0	16.6
,, ,, ..	22–23	Norfolk ..	—	28.4	20.3	24.3
Helston	21–22	Cornwall A.	11.8	39.2	27.7	26.2
,, ...	,,	,, ..	10.7	39.0	24.4	24.7
Baumforth Seedling A.	21–22	Essex	8.1	40.5	28.1	24.9
,, ,, ..	,,	Kent A. ..	11.6	32.6	16.6 (mosaic severe)	20.3
,, ...	22–23	Devon ..	—	8.9	16.5	12.7
Red Antwerp A. ..	21–22	Perthshire A...	4.3	22.0	13.5	13.3
,, ,, ..	,,	,, B...	3.6	13.0	19.3	12.0
Norwich Wonder ("Laxton").. ..	21–22	Perthshire C.—	4.8	24.2	22.2	17.0
Norwich Wonder ("Fillbasket") ..	22–23	Kent C. ..	—	9.2	30.6	19.9
,, ,, ..	,,	Kent A. ..	—	7.3	20.4	13.8
Storrie's Invincible "(Norwich Wonder" ?)	,,	Perthshire D...	—	11.5	20.4	15.9

Single rows of Pyne's Royal and Reader's Perfection, 360 feet long, were divided into twelve 30 foot lengths, each of which was picked separately throughout the season.

The average crop for each length, in ounces, was as follows :

Reader's Perfection	220.7	± 9.67
Pyne's Royal	212.5	± 5.81

The probable errors, expressed as per cents., are 4.38 per cent. and 2.73 per cent. respectively. This seems to us to indicate somewhat greater reliability than we had expected. But it must be repeated that very few of the figures in this report are based on material planted specially for cropping trials ; nearly all the material was planted specially for roguing, with a view to planting the main trials later.

Since mere weight of crop is by no means the only indication of a variety's commercial value, some notes on fruit qualities and time of ripening may perhaps be of value to readers.

The combination of qualities necessary to make a raspberry suitable for marketing in punnets is found, in our conditions, in only three or four varieties. Of these the best by far are Lloyd George and Pyne's Royal. Lloyd George is the better coloured and the better flavoured of these, but its fruit is only barely firm enough for the purpose ; and some people object to its shape as being too like that of a loganberry. The fruit of Pyne's Royal is firmer, and when well grown has a good smooth short-conical shape.

A promising variety fruited here for the first time in 1924 is North Ward, a Cornish sort which seems very difficult to obtain. In our conditions the fruit is larger than any variety except Lloyd George, and Pyne's Royal; it is nearly the same shape as Lloyd George, i.e., long conical, and of at least an equally good colour ; in firmness also it seems to meet requirements. A fourth variety which we ourselves have marketed in punnets is Norwich Wonder ; but of this variety the fruit is only large enough when well grown, and as the variety seems to have " off years " it cannot be relied on for the purpose. It has the disadvantage of a very short "strig," which makes it necessary to cut the fruits for punneting with sharp-pointed scissors. The flavour of the fruit is about the best of all raspberries. Storrie's Invincible appears to us to be identical with Norwich Wonder, but has produced stronger growth and larger fruit, two points in its favour. Hornet A. is often large enough for punneting, but its fruit is too soft, as is that of Profusion.

In the South of England many growers are in search of an early variety suitable for commercial use. The three varieties which prove here to be the earliest ripening are Mitchell's Seedling (Semper Fidelis B), Prior's Prolific, and Norwich Wonder. Of these the first and second have unfortunately suffered severely here from blue stripe wilt (" die back "), whilst the third as already stated is unreliable in cropping. They are, however, the only sorts that can be recommended for the purpose. Mitchell's is often known in Scotland as " Semper Fidelis ", but is quite distinct from the old English variety of that name. Bath's Perfection, which is early, succeeds nowadays in very few places, and cannot be recommended. Hornet A. also begins to ripen early, but the bulk of its crop is mid-season.

We sometimes also meet growers who want late varieties for extending their season. The latest of all is the variety which we now call " Hornet E. ", sometimes known as " Improved Hornet," or " Late Hornet ". This appears to be an excellent variety ; the fruit is of good size and produced in very large clusters ; even in Kent it seems usually to continue ripening well into August, (it has no tendency to flower on the new canes, and thus is not an autumn fruiter).

Next to this, one of the latest varieties is Devon ; a sort specially adapted to heavy soils. The bulk of the crop of Devon, however, would probably ripen on the average a good week before Hornet E.

We cannot of our own knowledge recommend varieties suitable for jam. We have often been told, however, that Baumforth A. and Semper Fidelis A. are about the best of all ; Pyne's Royal, Lloyd George, Mitchell's Seedling and Devon are also said to be good jammers. We have been told that amongst the worst are Baumforth B., Superlative and Norwich Wonder. Some jam makers appear to like both Red Cross and Bath's Perfection, whilst we know of cases where both varieties have turned out very poor jam ; perhaps the soil on which they are grown alters the jamming quality.

Finally, a few words may be added as to certain Continental varieties now on trial here. Winkler's Seedling appears to be a very heavy cropper ; the fruit is of very fine colour and good flavour, but in our conditions is distinctly small. If it will produce larger fruit in other soils it will be an extremely promising variety. Brown Hague has not cropped particularly well, and its fruit is of a rather dull purplish colour, but much larger than that of Winkler's.

A Dutch variety called " Roosjes " has cropped very well, and produced good sized fruit of fair colour. " Wilder," also from Holland, has cropped fairly well and appears to be distinctly late in ripening, probably later than Devon. A variety received from Holland as " Oude Zundertsche " proves to be identical with Hornet A.

SOME FACTORS INFLUENCING THE PERIOD OF BLOSSOMING OF APPLES AND PLUMS.

By R. G. HATTON and N. H. GRUBB.

In 1919 a commencement was made in the recording of the blossoming season of some fifteen varieties of Commercial Apples in the Pruning Plot, and a similar number of Plums in the Variety Plot. These records were taken primarily for the information of those working at the Station, but, since so many queries have been received from growers upon this subject, it has been decided to give here a brief outline of the results.

Although the records are nearly complete for seven years, it must not be supposed that we ourselves regard them as an entirely reliable guide.

There are, first of all, the difficulties of the actual recording, many of which have already been referred to by workers on this subject. What for instance is to be regarded as " full bloom " ? This must depend very largely on personal judgement. We have, therefore, tried to reduce this sort of error, as far as possible, by taking notes of the opening of the first flower, and the falling of the last, as well as trying to judge when fifty per cent. of the blossoms have opened. This last we have called " full bloom ". But each of these records raises problems of its own. In even the most carefully selected group of trees of a single variety, some variation has always been observed ; where these trees have been less carefully raised and selected the variation is certainly greater.

Such variation seems to be due to several causes, the most obvious of which will be the factors affecting amount of blossom. In any group of trees of bearing age, some are likely to be in their " off " year, and the resulting differences in the amount of blossom undoubtedly affect the length of the flowering period.

Again, proof has been obtained here—as will be shown later—of the effect both of different methods of pruning, and the use of different root-stocks, upon the blossoming period of any one variety. It is at least probable that other cultural factors, and insect attacks, may have similar effects.

In view of these variations, the records here have never been taken upon single trees. Groups of trees, from three to sixteen of any one variety, have been used for the observations, but unfortunately, in most cases, it has been impossible to keep individual tree records. The difficulty, then, arises, in recording, as to whether the " average " is to be taken, or whether the first opening blossom on the earliest tree in the series and the last dropping blossom on the latest are preferable. In order to reduce the human factor, this last course has been adopted and the average estimated only for the full blossoming. Even then a certain amount of personal judgment has to be exercised in disregarding " freaks " and peculiarities of certain trees. In this matter there may be a

further element of error in our records owing to the fact that no less than six persons have during the period been concerned with these observations.

Whilst the writers made every endeavour to establish a uniform method of observation, the actual records in different seasons were also taken by Messrs. J. Amos, T. N. Hoblyn, H. M. Tydeman, and Misses A. D. Mackenzie and K. P. Worsley, to whom the best thanks are due for making this survey possible. On the other hand, the period of time over which the observations have been made, and their generally consistent character, encourage the hope that the error is, after all, not so very great.

In the case of Apples, a diagram is presented showing the average period of Blossoming on unpruned trees from 1919 to 1925. The pruning factor is thus eliminated. The trees were purchased from ordinary commercial sources, some, as it has transpired from suckers, on true, and some on mixed " Paradise," and others on variable Seedling " Crab " Stocks. The varieties of " Paradise " identified are generally those in most common use, Types II. (Doucin) and V. (Improved Doucin) predominating. As will be seen later, those trees which are worked upon Type II. may be slightly earlier in their blossoming period than those on Types III. (" Holly Leaf ") V., and VI. (Nonsuch). Despite these factors of variability, and that of the Seedling " Crab " Stocks, we get an "average " grouping in the varieties into early, mid-season and late, which is very generally borne out by a study of the year to year records.

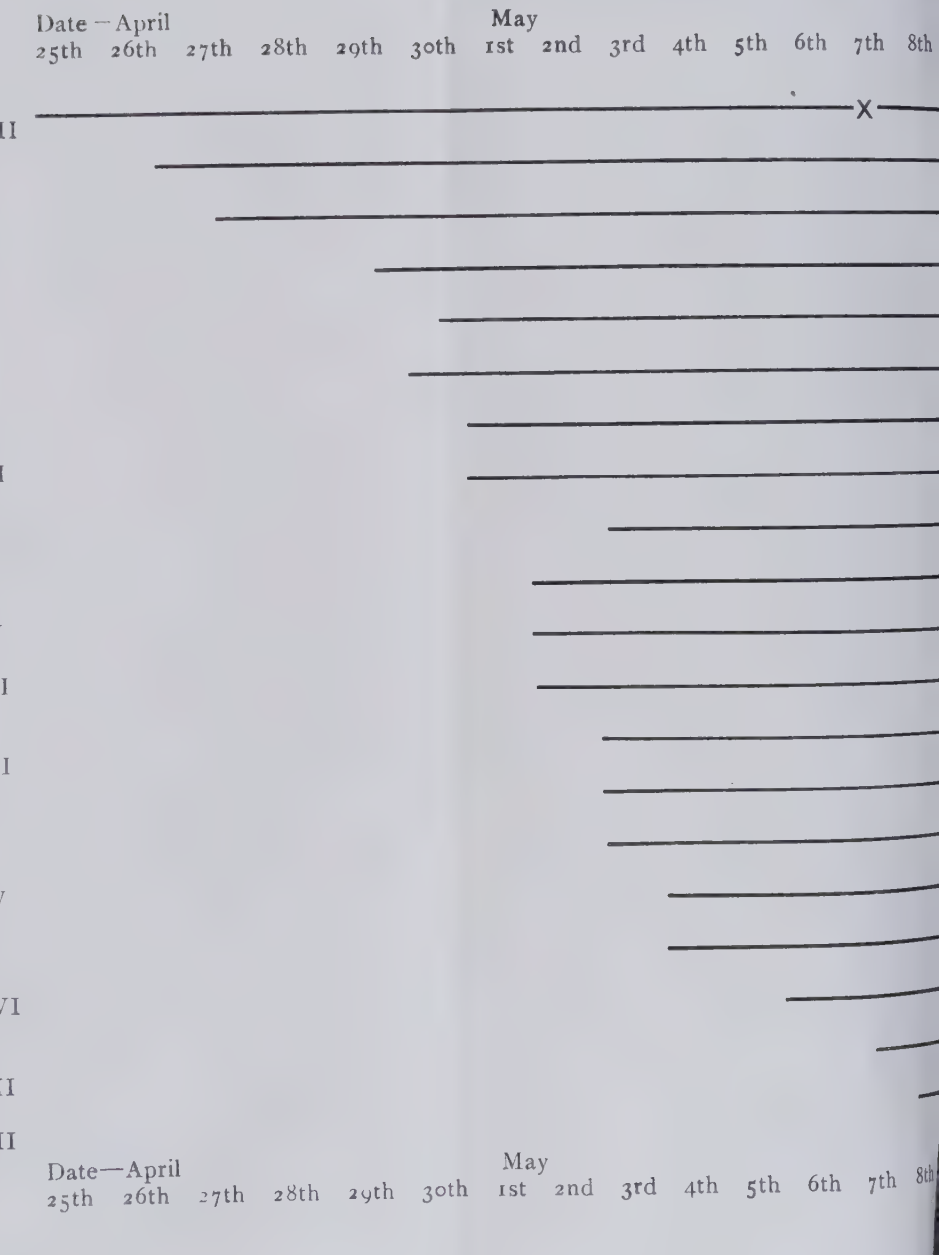
It is very satisfactory to find that this natural grouping and order very closely coincide with those recently published by Mr. Cecil Hooper, F.L.S., of the S.E.A. College, Wye, in the " Fruit, Flower and Vegetable Trades' Journal " of December 20th and 27th, 1924, and re-issued as Fruit Bulletin 10—S.E.A. College, Wye. Mr. Hooper's table is a compilation not only of his own records at Wye but of those from Wisley, Droitwich, Woburn and Long Ashton, so that the evidence from all these sources would seem to confirm the value of at least a rough grouping of varieties into Early, Mid-season, and Late Blossoming.

Whilst it is clear that under East Malling conditions a lack of precise knowledge on the question of the relative blossoming season would not have led us into any grave disasters in planting together most of our Apple varieties (since they so generally overlap), there is little doubt that between the earliest and latest groups cross pollination might have been unsatisfactory. Seasonal vagaries actually increase this risk, as for example, in the year 1921, when Beauty of Bath was " full " on April 14th and Annie Elizabeth only started to open upon the 25th. However, fortunately for the apple grower, most of the main commercial varieties (including Bramley's Seedling, not yet dealt with in our records) fall into a very close mid-season group, of which any two varieties may be regarded as generally likely to overlap.

TABLE I.

DIAGRAM SHOWING PERIOD OF

Variety.	Root-stock where known.
Beauty of Bath ..	Paradise Types V, III & II
Norfolk Beauty ..	Paradise
Bismarck ..	Seedling 'Crab'
Gladstone ..	Paradise Type V
,, ..	Seedling 'Crab'
Grieve, James	Seedling 'Crab'
,, ..	Paradise Types V & II
Grenadier ..	Paradise Type II
,, ..	Seedling 'Crab'
Cox's Orange P.	Paradise Types II & III
Allington P.	Paradise Type V
Rival ..	Paradise Type II
Worcester Pearmain	Paradise Type II
,, ..	Seedling 'Crab'
Lane's P. Albert ..	Seedling 'Crab'
Derby, Lord	Paradise Type V
Early Victoria	Seedling 'Crab'
,, ,,	Paradise Type VI
Newton Wonder ..	Paradise Type II
Annie Elizabeth ..	Paradise Type II



LOSSOMING OF APPLES ON UNPRUNED TREES. 1919-1925.

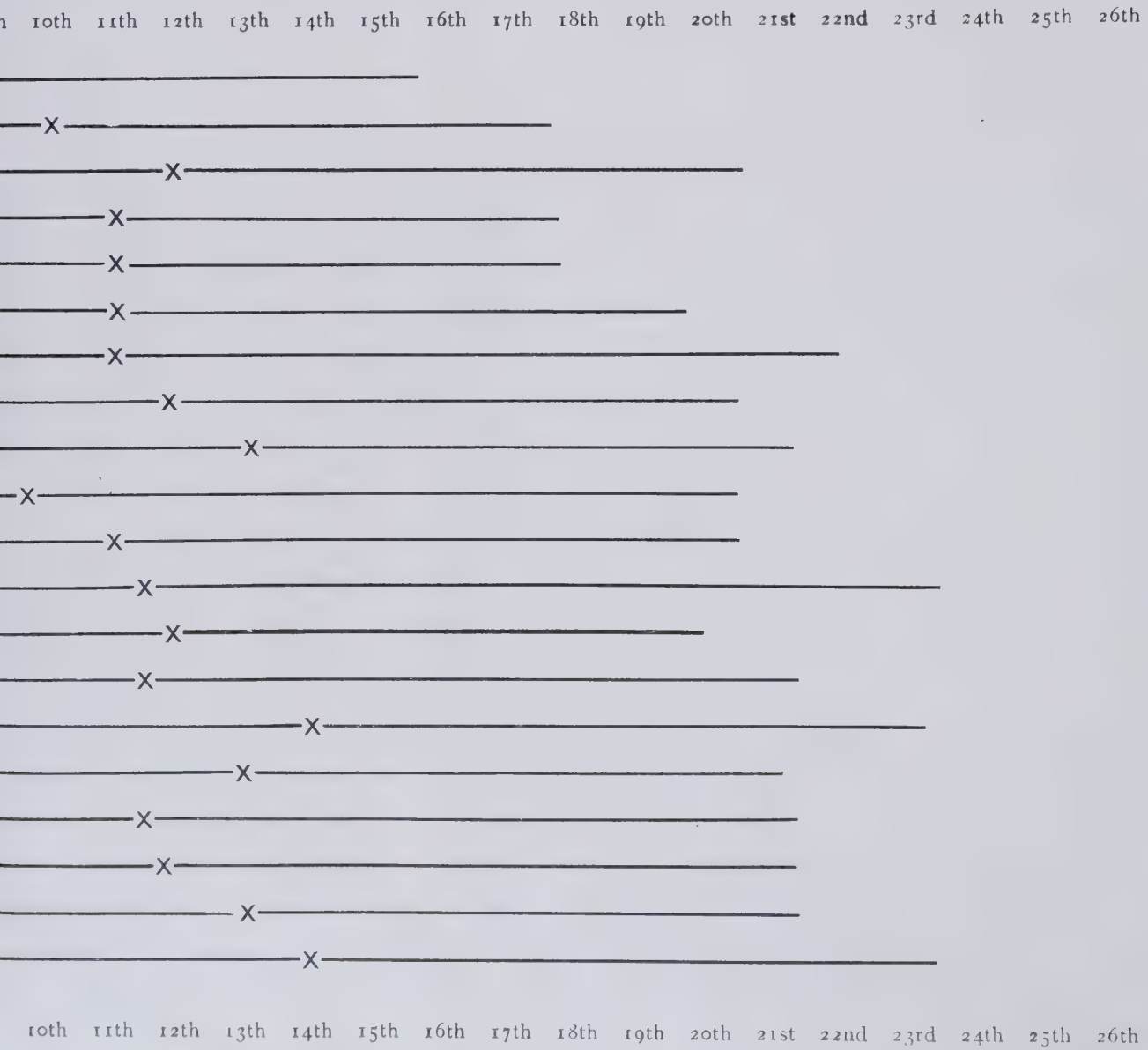

h 10th 11th 12th 13th 14th 15th 16th 17th 18th 19th 20th 21st 22nd 23rd 24th 25th 26th
10th 11th 12th 13th 14th 15th 16th 17th 18th 19th 20th 21st 22nd 23rd 24th 25th 26th

TABLE II.

RELATIVE ORDER OF FULL FLOWERING OF APPLES FROM YEAR TO YEAR.

UNPRUNED TREES.

Variety.	Stock.	1919	1920	1921	1922	1923	1924	1925	Average. Position.
Beauty of Bath ..	P	1 *May 13th*	1 *Apl. 15th*	1 *Apl. 14th*	1 *May 17th*	1 *May 1st*	1 *May 15th*	1 *May 13th*	1
Norwich Beauty	P	2 ,, *14th*	2 ,, *17th*	3 ,, *27th*	2 ,, *19th*	2 ,, *2nd*	1 ,, *15th*	2 ,, *14th*	2
Bismarck ..	S	12 ,, *16th*	9 ,, *22nd*	7 ,, *29th*	9 ,, *21st*	4 ,, *3rd*	4 ,, *16th*	5 ,, *16th*	7.1
Gladstone ..	P	5 ,, *15th*	— —	7 ,, *29th*	2 ,, *19th*	4 ,, *3rd*	11 ,, *17th*	2 ,, *14th*	6.2
James Grieve ..	P	5 ,, *15th*	3 ,, *19th*	2 ,, *26th*	4 ,, *20th*	2 ,, *2nd*	4 ,, *16th*	5 ,, *16th*	3.7
Grenadier ..	P	2 ,, *14th*	3 ,, *19th*	7 ,, *29th*	4 ,, *20th*	4 ,, *3rd*	4 ,, *16th*	12 ,, *19th*	5.1
Coxs' O.P. ..	P	5 ,, *15th*	6 ,, *21st*	6 ,, *28th*	4 ,, *20th*	4 ,, *3rd*	4 ,, *16th*	4 ,, *15th*	4.7
Allington ..	P	5 ,, *15th*	5 ,, *20th*	3 ,, *27th*	4 ,, *20th*	4 ,, *3rd*	4 ,, *16th*	8 ,, *17th*	4.7
Rival ..	P	5 ,, *15th*	6 ,, *21st*	3 ,, *27th*	9 ,, *21st*	4 ,, *3rd*	4 ,, *16th*	8 ,, *17th*	5.6
Worcester ..	P	5 ,, *15th*	9 ,, *22nd*	10 ,, *30th*	4 ,, *20th*	4 ,, *3rd*	4 ,, *16th*	5 ,, *16th*	5.9
Lanes' P.A. ..	S	12 ,, *16th*	12 ,, *25th*	15 *May 4th*	9 ,, *21st*	13 ,, *5th*	13 ,, *19th*	12 ,, *19th*	12.3
Lord Derby ..	P	12 , *16th*	— —	10 *Apr. 30th*	9 ,, *21st*	13 ,, *5th*	13 ,, *19th*	12 ,, *19th*	11.5
E. Victoria ..	P	5 ,, *15th*	6 ,, *21st*	12 *May 1st*	9 ,, *21st*	4 ,, *3rd*	1 ,, *15th*	8 ,, *17th*	6.4
Newton Wonder	P	15 ,, *17th*	11 ,, *23rd*	13 ,, *3rd*	9 ,, *21st*	12 ,, *4th*	11 ,, *17th*	11 ,, *18th*	11.7
A. Elizabeth ..	P	2 ,, *14th*	— —	13 ,, *3rd*	15 ,, *23rd*	13 ,, *5th*	13 ,, *19th*	12 ,, *19th*	11.3

P. Paradise. S. Seedling.

The question of the suitable interpollenation of varieties of Apples is not here considered, since to the writers' knowledge no cases of intersterility in this fruit have so far been authenticated.

Table II. shows to what extent the relative order of flowering has been maintained from season to season in our conditions, and the dates of full flowering illustrate very well the wide differences in the actual time of blossoming of any individual variety owing to seasonal influences.

These dates again show how seasonal conditions from year to year shorten or lengthen the relative blossoming period. For instance, while in 1921 twenty days elapsed between the full blossoming of Beauty of Bath and that of Lane's Prince Albert, in 1919, 1923 and 1924, the biggest differences were only four days.

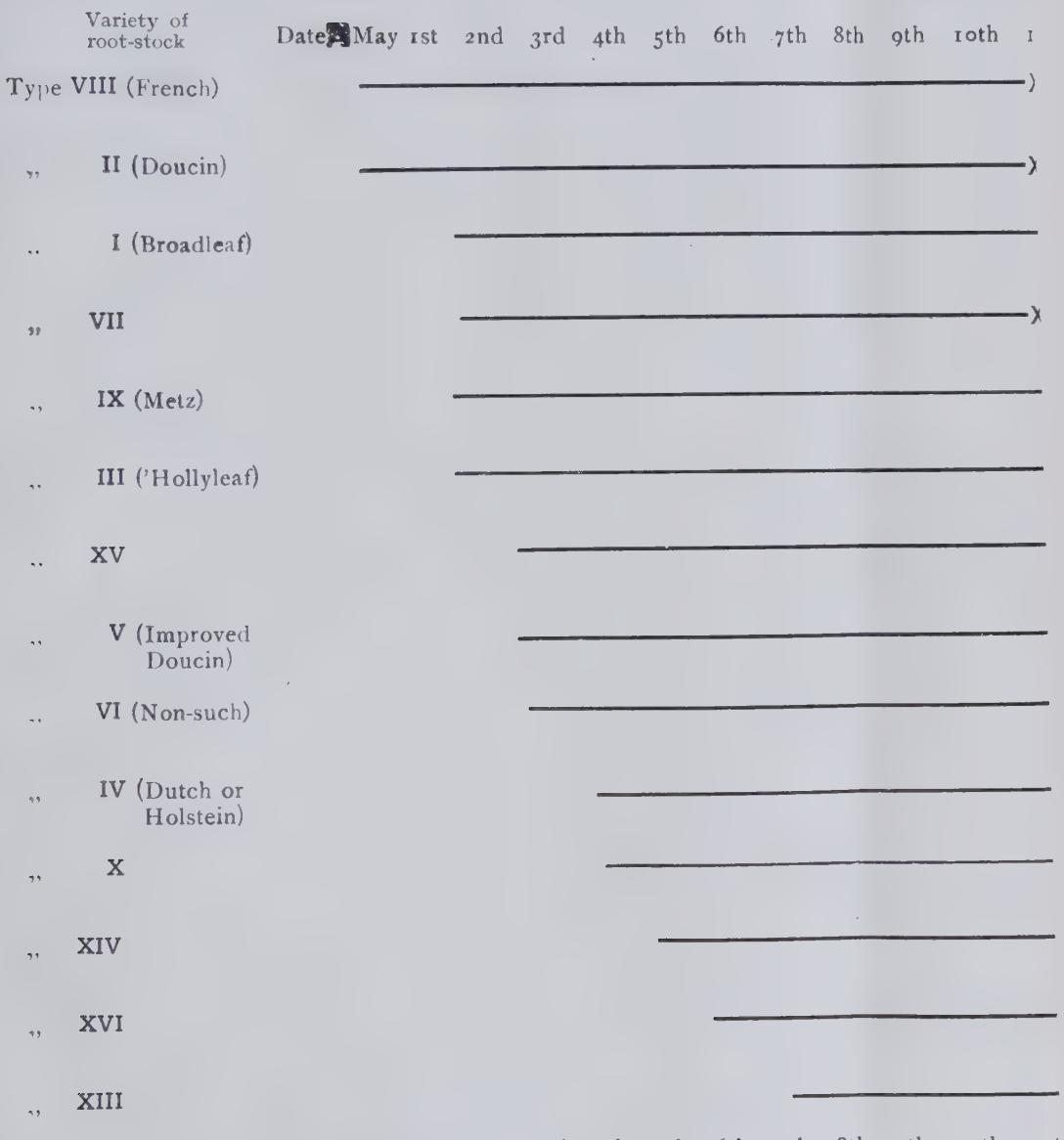
It has already been mentioned that our records show a difference in blossoming period between pruned (tipped and spurred) and unpruned or merely " thinned " trees, of the same variety. This observation is mainly of importance to the research worker ; not only does it indicate the extreme caution necessary in selecting trees for such observations, but also it is suggestive that the reason of the difference appears to lie in the classes of fruit buds predominating on the tipped and untipped trees. It seems to be the case here, that terminal fruit buds (on long shoots) are mostly early in their opening ; spur fruit buds (on short shoots) are mainly mid-season ; whilst axillary fruit buds are nearly always late. In the system of tipping and spurring here concerned, the terminal fruit buds are almost entirely removed, and axillary fruit buds largely so, and thus the blossoming season is apt to be " telescoped." There is some evidence to show that this effect of pruning varies not only from season to season, but also probably from variety to variety. The two varieties which blossomed most freely at East Malling on the pruned trees in their early years, Newton Wonder and Beauty of Bath, show the effect less clearly than most of the remainder. It also seems probable that this effect is tending to disappear as the trees get older, the reason presumably being that the bulk of the fruit buds on all the trees are then on spurs.

However, even as late as 1923, the tenth year from planting, we recorded the unpruned trees of Lane's Prince Albert as starting into blossom nine days earlier than the pruned trees, and in that year on the average, all the varieties taken together showed that the unpruned trees started to blossom nearly four days earlier than the pruned trees. There have actually been cases where the unpruned trees have been as much as fifteen days in advance of their pruned neighbours of the same variety. From the point of view of " delayed dormant " spraying such a difference as this might even be of economic importance.

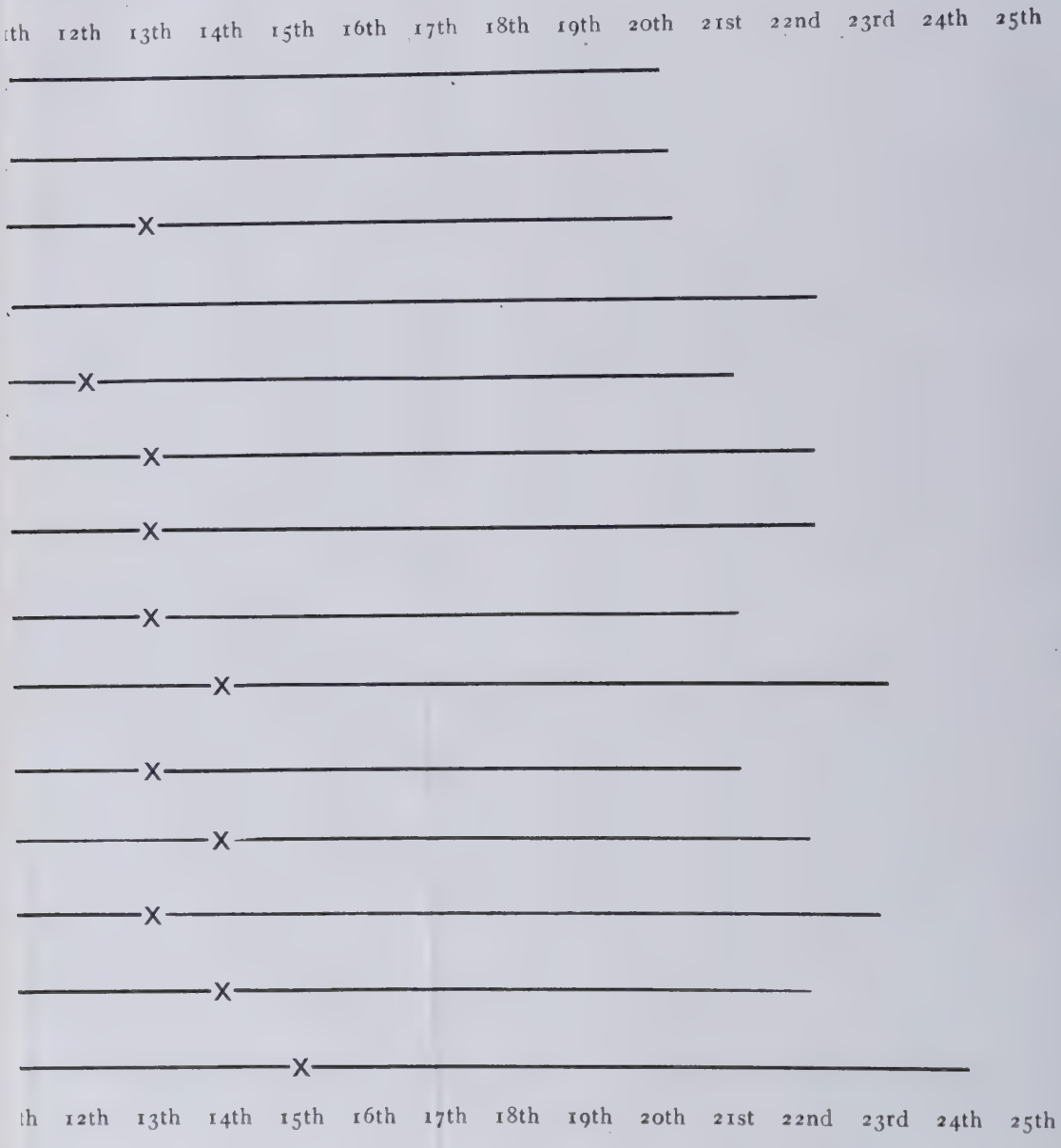
The influence of the root-stock upon the blossoming period of its scion has been definitely recorded for three seasons, now that all the trees have a

TABLE III.

DIAGRAM SHOWING VARIATIONS IN BLOSSOM ROOT-S


Variety of root-stock
Date May 1st 2nd 3rd 4th 5th 6th 7th 8th 9th 10th 1
Type VIII (French)
,, II (Doucin)
,, I (Broadleaf)
,, VII
,, IX (Metz)
,, III ('Hollyleaf)
,, XV
,, V (Improved Doucin)
,, VI (Non-such)
,, IV (Dutch or Holstein)
,, X
,, XIV
,, XVI
,, XIII
Date May 1st 2nd 3rd 4th 5th 6th 7th 8th 9th 10th 11t

ING PERIOD OF LANE'S PRINCE ALBERT APPLE ON DIFFERENT
'OCKS 1923-25.


th 12th 13th 14th 15th 16th 17th 18th 19th 20th 21st 22nd 23rd 24th 25th
th 12th 13th 14th 15th 16th 17th 18th 19th 20th 21st 22nd 23rd 24th 25th

Seven-Year-Old Lane's P. Albert Apple on Rootstock, Type IX.
Showing much blossom open on May 14th.

Seven-Year-Old Lane's P. Albert Apple on Rootstock, Type XIII.
Showing blossom still unopened on May 14th.

considerable amount of blossom. These records have been taken upon five unpruned trees on each stock, and they seem to show that, at least in the early years, this factor is an influence to be reckoned with. Indeed, on our plots of Lane's Prince Albert, where the trees on different root-stocks are intermixed, the difficulties of spraying the trees immediately before and after blossoming have been greatly increased by this factor of successional flowering.

Table III. shows diagrammatically the variation in blossoming period of Lane's Prince Albert on different root-stocks. It will be seen that on the average of three years a single variety may vary from this cause to the extent of seven days in its first opening, and four days in full blossoming. In individual seasons the difference has been as great as ten days. Indeed, the difference has been so marked, and has persisted so late into the season, that growers unknowingly have remarked on the very different stages of development of the set fruits. The illustrations (Plates I. and II.) show typical trees of Lane's Prince Albert upon two different stocks in closely adjacent rows photographed on the same day.

The effects of root-stock upon the period of blossoming are not confined to our soil and situation only; identical data has been collected from our trial plots upon other soils. They do not appear to be in any way connected with the different times of blossoming of the different classes of fruit buds already mentioned in discussing the effects of pruning. If this were the case, we should expect to find the relative order a very different one. As already mentioned, axillary fruit buds tend to be late and yet trees on those stocks which show the strongest tendency to their formation happen to be amongst the earliest flowering, and vice versa.

At present no reasoned explanation of the phenomenon can be given, for although the more precocious and dwarfed root-stocks are mainly grouped at one end, and the most vigorous ones at the other, there are exceptions. Again, though it is true that Type VIII. comes into leaf itself very early and Type XIII. rather late, yet contradictory evidence could be quoted. Indeed we can site a case of the early leafing and blossoming Malus Baccata being fully "out" whilst the suckers from the root-stock upon which it is worked are still quite dormant! The evidence in the case of plums is equally strong and contradictory. Plums worked upon the early leafing and flowering Myrobolan (P. Cerasifera) Stock are amongst the latest to come into blossom if compared with the same varieties upon the late blossoming Pershore Stock.

This brings us to the consideration of our records on the blossoming of Plums, which are presented in diagrammatic form in Table IV. Unfortunately the average blossoming period of the Cherry Plum (Myrobolan, P. Cerasifera), to which reference has just been made, cannot be included upon the diagram

because it extends from March 2nd until April 3rd, and so does not overlap with any of the P. Domestica and P. Insititia varieties included in the table.

The records have been taken on groups of three trees of each variety. The trees were bought for a variety plot upon various root-stocks, most of which have since been identified from their suckers. The trees have only been lightly thinned occasionally.

As in the case of Apples, we have records to show that the root-stock to some extent affects the time of blossoming. Victorias, Czars and other varieties appear to come into blossom considerably earlier on Common Mussel and Pershore Stocks than they do on Brussel and Myrobolan roots. Intermediate between these two groups of stocks the other varieties seem to range themselves.

Our two illustrations, (Plates III. and IV.) showing typical adjacent trees of Victoria Plum upon different root-stocks, bear witness to stock effect on time of blossoming very well. Unfortunately, the incidence of " Silver Leaf," " Die Back," etc., amongst our experimental plum trees, has so thinned out their numbers and cut across our recording that we cannot yet present the amount of data that we can in the case of Apples; however, the same effects have been noticed on more than one soil. How far it may be possible to utilise advantageously this control of the earliness and lateness of blossoming depends upon the range of effect that can be established. It must be remembered that up to the present, in the main, only stocks in general commerce have been selected and tested, and that, as yet, no selections have been made from this particular point of view. Indeed, until we know the cause of the influence, we have no better basis of selection than chance, since the season of the stock itself is a misleading guide.

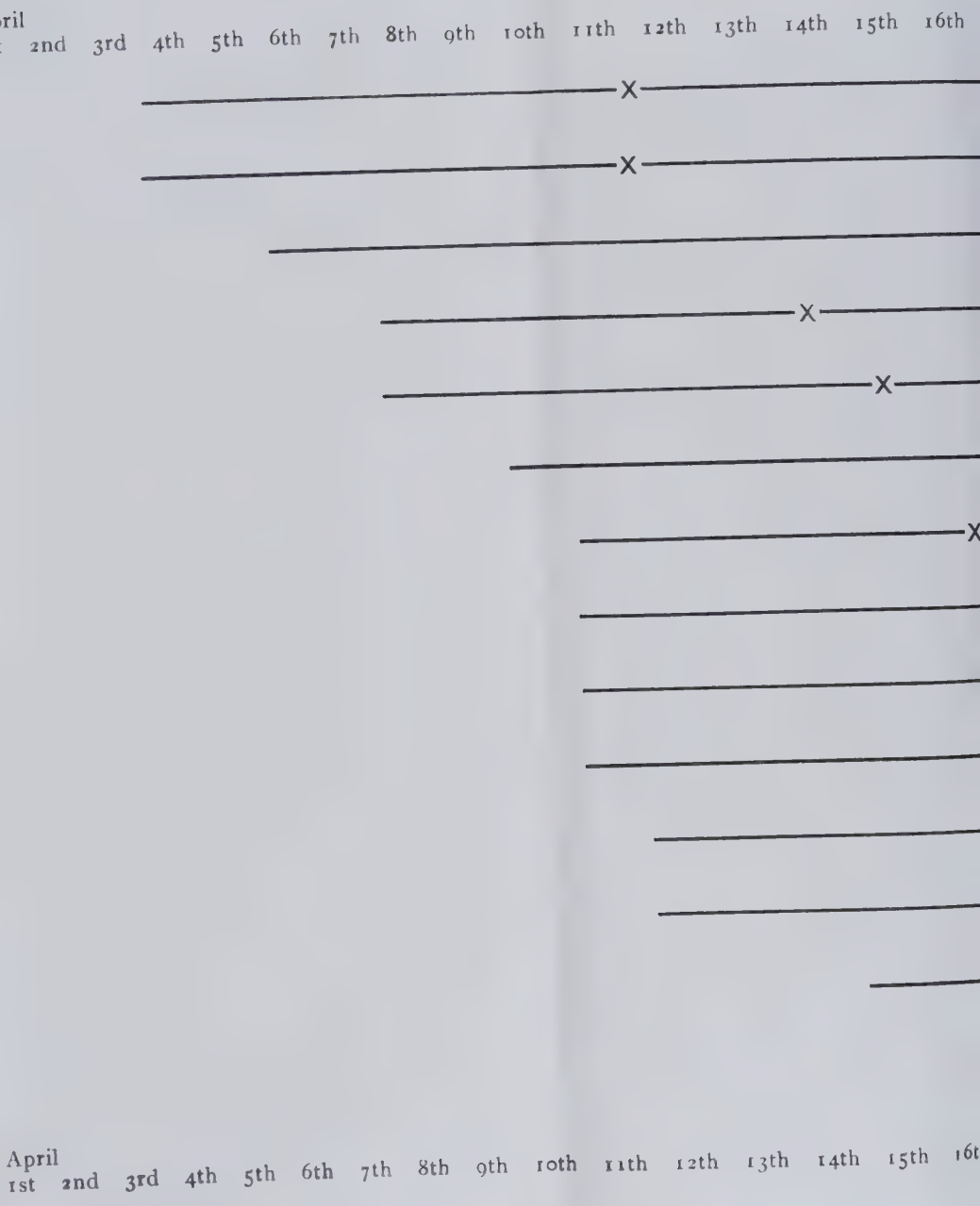
With regard to our actual order of blossoming, it is again encouraging to find that this agrees very generally with Mr. Cecil Hooper's compiled list, where we can feel confident that our varieties are the same. There are, however, two notable exceptions. Both Czar and Belle de Louvain come very much earlier in our list. It will be noted, however, that in our plots both these are worked on Common Mussel which, as we have already said, makes for early flowering.

Our list can only be taken as a very general guide to the relative blossoming period and we have made no experiments with regard to intersterility. For this aspect of the question, reference should be made to the publications of Mr. M. B. Crane, John Innes Horticultural Institution, Merton, Surrey, and Mr. A. N. Rawes, of the Royal Horticultural Society's Gardens, Wisley.

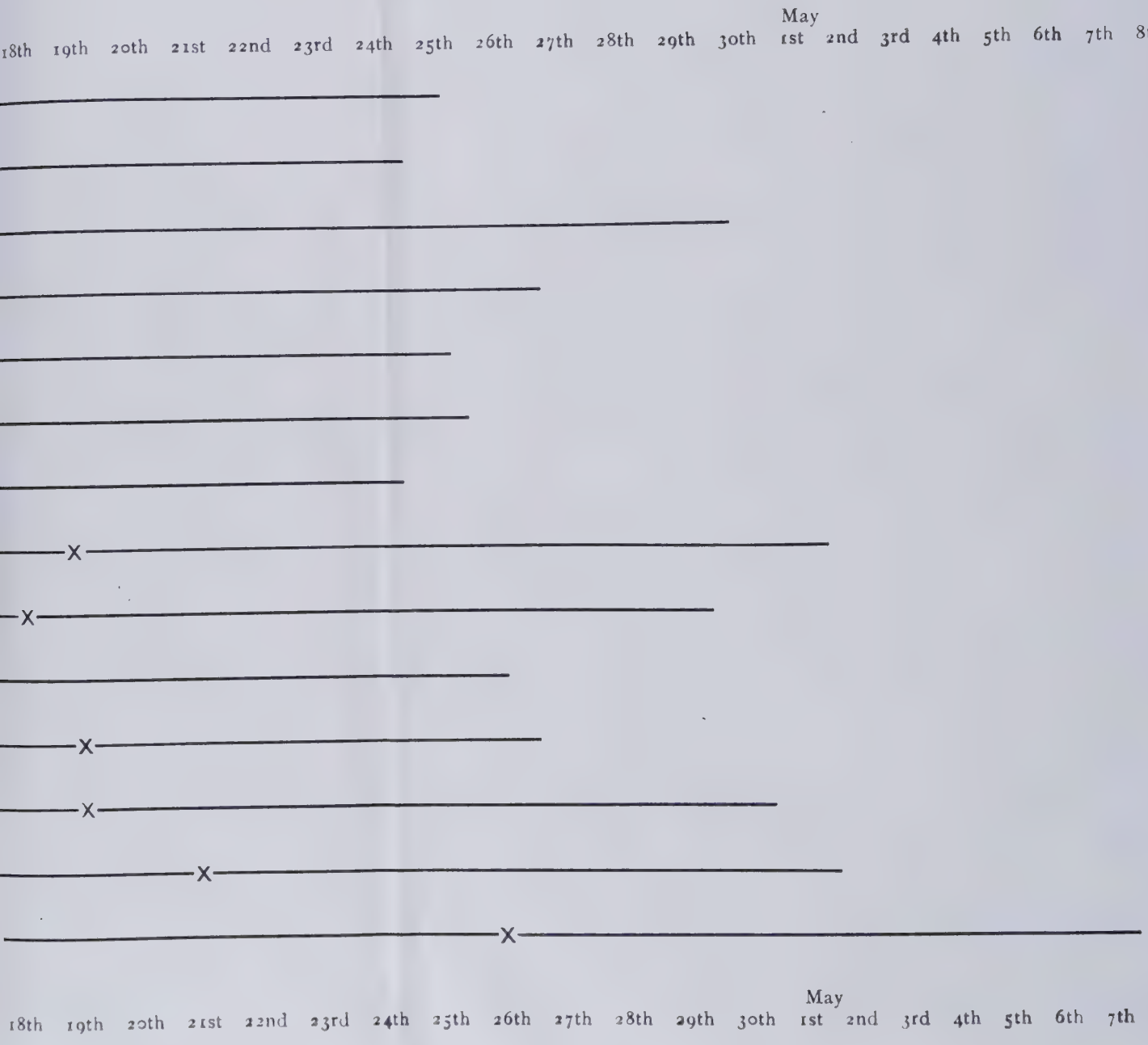
TABLE IV.

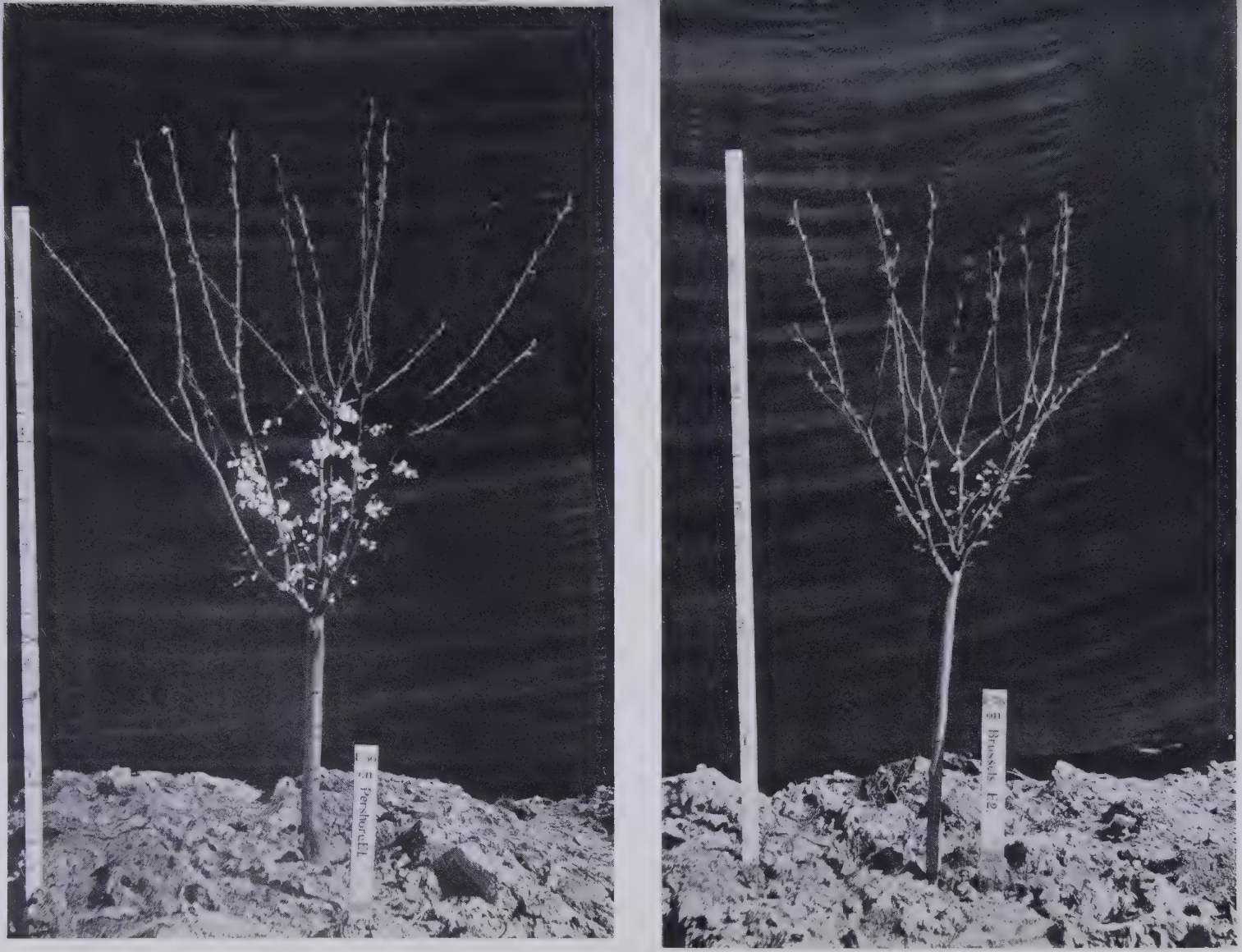
DIAGRAM SHOWING PERIOD OF BLO

Variety.	Root-stock where known.
Monarch	Com. Mussel
Black Diamond	Mixed Mussel
Black Bullace	Seedling Damas
Greengage	Seedling Damas
Belle de Louvain	Com. Mussel
Denniston's Gage	Mixed Mussel
Early Prolific, Rivers	Brompton
Czar	Com. Mussel
Giant Prune, Burbank's	Com. Mussel
Victoria	Brompton
White Magnum Bonum	Brompton
Shropshire Prune Damson	Mixed Mussel
Pershore Yellow Egg	Own Roots
Pond's Seedling	Probably Seedling St. Julien


April
1st 2nd 3rd 4th 5th 6th 7th 8th 9th 10th 11th 12th 13th 14th 15th 16th
April
1st 2nd 3rd 4th 5th 6th 7th 8th 9th 10th 11th 12th 13th 14th 15th

ING OF PLUMS—AVERAGE OF 5-7 YEARS.


May
18th 19th 20th 21st 22nd 23rd 24th 25th 26th 27th 28th 29th 30th 1st 2nd 3rd 4th 5th 6th 7th 8th
May
18th 19th 20th 21st 22nd 23rd 24th 25th 26th 27th 28th 29th 30th 1st 2nd 3rd 4th 5th 6th 7th 8th



Adjacent Four-Year-Old Victoria Plum Trees on Different Rootstocks, Photographed April 4th, 1923.
Note Rootstock effect on time of blossom opening.

CHERRY STOCKS:

Their Behaviour in the Nursery.

By N. H. GRUBB and A. W. WITT.

Brief notes on the investigations into cherry stocks which are being carried on at this station have appeared from time to time in previous Annual Reports. The work has now reached a stage at which a description of the material we are using, and its comparison with the cherry stocks commonly employed, may be of considerable interest to both tree raisers and cherry growers.

Our cherry stock investigations were begun in the same way as the investigations into other fruit tree stocks, by securing from raisers and dealers small collections of the different classes of cherry stocks which they were able to supply. Of twelve collections of stocks obtained in this way, which were presumably representative of the cherry stocks in common use, six were received under the name "Common," one as "Mazzard," one as "Black Mazzard," one as "Cerasus austera," and the remaining three as "Mahaleb." As was expected, these stocks were found to belong to three different botanical species: Prunus Avium, the sweet cherry, Mazzard, Gean, or Gaskin, represented by the "Mazzard," "Black Mazzard," and most of the "Common" stocks; Prunus cerasus, the acid cherry, represented by "Cerasus austera" and one of the collections called "Common"; and Prunus Mahaleb.

Most of these stocks were seedlings, though one or two collections were claimed to be suckers from seedling wild cherries. In either case they could be expected to show considerable variation. An attempt was therefore begun immediately to propagate some of them vegetatively; at least half of each collection was planted especially for the purpose of layering, the rest being allowed to grow on unpruned in order to show the extent of variation likely to be found in such collections, in growth, blossom and fruit characters.

In this last mentioned unpruned row of stocks the expected variation quickly appeared; and by the time they were six years old, many having then produced blossoms and fruit, it was clear that the extent of the variation was even greater than could have been predicted. There were wide differences between individual specimens within each of the various collections; they differed surprisingly in vigour and habit of growth, in time of blossoming and leafing out, and in time of ripening, colour, size, and flavour of fruit.

At the same time, differences appeared in the rows planted for layering. A considerable number of the sweet cherry stocks proved to be quite easily rooted from layers; and there were differences in the amount of rooting obtained from layers of acid cherry and Mahaleb stocks, though none of these so far tried has

proved to be easily enough rooted in this way to be commercially practicable. Other methods of vegetative propagation are being tried with these two classes of stock ; and at the same time further batches of seedlings are being layered in the hope of obtaining more easily rooted forms. This work has not yet reached a stage at which a report can be made ; the remainder of this article will therefore deal with the results obtained in propagating sweet cherry stocks from layers.

Since wide variation had appeared in the unpruned row of cherry stocks, it was clear that each plant layered must be treated as a distinct individual, and the rooted layers kept separate from those of other plants. This naturally, delayed the work considerably, all the layers of the early years being required for fresh stools. It had, however, the advantage that all our selections are known to be clones. It was not until the winter of 1920-21 that any layers of even the most prolific selections could be spared for working, and then only in small numbers ; but in the following winter considerable numbers of some twelve or more selections were planted out in nursery rows. It was decided that most of these should be " run up " in the customary Kentish way, for grafting or budding at standard height with the varieties chosen for the stock trials ; the remainder were budded near ground level with the variety Morello, which was chosen for trial in the form of bush trees.

The stocks " run up " for working have demonstrated in a most striking way the degree of uniformity obtainable through vegetative propagation. All the stocks were allowed to grow for one year, and were then cut down to about one foot from the ground ; those " run up " were afterwards allowed to grow for two years, the " feathers " (stem shoots) being pinched at intervals in the summer, and shortened to about one inch in winter. See Plate V. showing these stocks at three years from planting.

For purposes of comparison measurements were made of a consecutive series of seedling stocks in a commercial nursery. These stocks had been four years planted ; they were growing in soil very similar to that at this Station, but probably received less individual care than our own stocks. The comparison may not be altogether fair, since the raiser complained that this was an unusually bad lot of stocks. On the other hand, the row selected for measuring comprised the best stocks in the whole plot. A further comparison with a much larger batch of seedling stocks in another nursery again showed considerably less than fifty per cent. of the stocks fit to work in four years ; and these stocks had been specially selected as first grade material !

Table I. shows the percentage of stocks in each of our selections, and in the measured batch of seedling stocks, which were considered large enough to bud or graft at 5 feet 6 inches from the ground : the number of stocks which had died since planting is also indicated. In each case those damaged in cultivation or otherwise are excluded.

TABLE I.

Proportion of Cherry Stocks fit for working standard high.

Layered Stocks Selection	Total planted excluding those broken in cultivation.	Dead.	Too Small	Fit to work standard high in *three* years.	
				Number	Per cent.
F1/1	24	0	0	24	100
F2/1	30	0	0	30	100
F2/2	23	0	4	19	82.6
F5/1	24	0	0	24	100
F5/2	29	0	0	29	100
F5/3	22	0	2	20	90.9
F5/4	34	1	0	33	97.1
F5/5	18	1	0	17	94.4
F9/1	21	0	0	21	100
F12/1	25	0	0	25	100
F12/2	11	2	0	9	81.8
F12/3	23	5	3	15	65.2
F12/4	30	0	0	30	100
F12/5	5	0	0	5	100
Average of 14 Selections	319	9	9	301	94.3
				in *four* years	
Seedlings	99	50	16	33	33.3

Thus, even if we include all of our fourteen selections, some of which we consider too lacking in vigour to be suitable for " running up," whilst others, like $\frac{F12}{3}$ will probably be discarded owing to some loss in transplanting, we still get over ninety-four per cent. fit for working in three years. Of the seedlings, after four years less than thirty-four per cent. were comparable with the bulk of our layers, and even these were not on the average nearly so tall as several of our selections.

It is not, of course, possible to compare the growth of our layered stocks " run up " for working in situ with that of seedling and sucker cherries transplanted from the woods when already tall enough to work. These latter will undoubtedly be less variable than stocks raised from seed, since only the most vigorous are selected for transplanting; since at best they are groups of suckers from varying seedlings it is impossible for them to be as uniform as our clone layers. The only particulars in which the two classes of stock can be compared are, first in cost, and secondly in uniformity of the resulting trees. On the latter point we have as yet no data; so far as cost is concerned, we believe our best layered selections will compare very favourably with the wild cherries, especially when allowance is made for the admittedly heavy loss in the latter after-transplanting into the nursery. In addition, most of our selections, when tall enough for working, have stems on the average far stouter than those of any wild stocks six feet high which we have yet seen. We have not yet been able to obtain any figures to show this difference. Most of our layered selections, also, when tall enough for working, are extremely well anchored, which can hardly be said of much of the transplanted material.

The great uniformity of our layered stocks has already been mentioned. This is well seen in Plate V. which shows the whole twenty-five stocks of the selection $\frac{F12}{1}$ from a point near the end of the row. This particular selection is one of the most vigorous we have yet obtained; it is not, however, quite the most uniform, judged by the " probable error," a figure which may be taken by the grower to indicate roughly the extent of variability within each group (see article on Black Currant Variety Trials, page 54). It may be of interest to compare the " probable errors " of the average heights of our leading selections after three years' growth with that of the average height of the thirty-three seedlings already mentioned as being the only stocks fit to work out of ninety-nine planted four years previously. This is shown in Table II.

Since there are more of the seedling stocks than of any single selection, had their uniformity been equal, the probable error of the seedlings should have been the lowest; and it must be repeated again that two-thirds of the seedling stocks have already been excluded, as being either dead or too small for working.

PLATE V.

Layered Cherry Stocks; Three Years Planted.
Note uniform height.

TABLE II.

Average Heights with Probable Errors.

Selection.	No. of Trees.	Average Height, centimetres. *Three* year's growth.	Probable Error.	Do. as per cent. of average.
F1/1	24	235	±1.34	.57
F5/1	24	246	±1.50	.61
F9/1	21	264	±1.77	.67
F12/1	25	256	±1.53	.60
		Four year's growth		
Seedlings	33	207	±2.14	1.03

This far greater uniformity of the layered stocks may be confidently ascribed chiefly to the elimination of seedling variability. The fact of the existence of this variation is shown again by the wide differences in many characteristics between our various selections. The differences appear at present to be as wide amongst those selected from any single collection from a single source (e.g., F12/1, F12/2, F12/3, etc.,) as between those from different collections. These differences are already known to extend in our selections, to the following characteristics :

Length, stoutness, straightness and colour of wood growth, number of "feathers," shape and pose of leaf, ease of rooting, depth and spread of root system, and relative amounts of coarse and fibrous roots. Thus F12/1 is by far the stoutest wooded and the stiffest of all our selections ; F9/1 is the tallest, but is not so stout wooded or so stiff as F12/1 ; F9/1 is also unique in making practically no "feathers" or laterals on the current year's growth, however strong ; F1/1 is weaker than either of the above, but makes an immense number of "feathers." F9/1 is usually found to have the best balanced and most symmetrical root system ; while F5/1 makes a large quantity of fibrous roots at the "collar,"

like a Broadleaf or Nonsuch Paradise Apple stock. These are merely examples of differences which presumably distinguish, in greater or less degree, the great majority of seedling sweet cherry stocks from each other.

The similarity of these differences to those found amongst apple stocks is very striking. We have not yet found differences in vigour as great amongst sweet cherry stocks as those amongst apple stocks ; but there appears to be no reason why even this should not eventually be done, if it should be thought desirable. And if the acid cherry stocks are included, the range in vigour is already as great.

Advance has been made with cherry stocks, then, along two lines : first, a means of obtaining uniformity, and second, the perpetuation of apparently desirable stocks.

The further question whether any of the differences are passed on to the scion, or whether the stock will influence the scion in any striking way, as is now known to be the case with apples and plums, must be left for the future to decide. The first worked trees of sweet cherries on any of these selections were planted out in permanent quarters during the past winter ; they are still too young to give any clear indications. Bush trees of Morello cherry on several of the selections are now in their third year, but even these are not yet old enough to give more than slight indications of stock influence. They should begin to crop in 1926, and may then show differences not at present discernible.

THE CHOICE OF YOUNG FRUIT TREES.

A popular survey of the present root stock position contributed to "Notes for Fruit Growers" in the Journal of the Kent Farmers' Union, September, October and November, 1924, and reprinted therefrom.

By R. G. HATTON, J. AMOS and N. H. GRUBB.

Apples.

At this season of the year the wise grower who intends planting this winter will be looking around to find the most suitable material for his purpose. During recent years a considerable amount of data has been presented, based on actual figures, to help him in his choice.

In the case of the top fruits more accurate knowledge is now to hand, in many cases, with regard to the "make up" of the tree, and the effect of that "make-up"—a combination of stock and scion—upon its ultimate performance. These facts are well worth reviewing before making final plans for a new plantation, for how many hundreds of acres have not been spoiled or even ruined because the material planted did not come up to expectations? In many cases this was not the fault of the material, which may have been excellent, but of the buyer and planner of the plantation who did not know how to use it properly. The overcrowded plantations, the temporary "filler" trees that only filled the space and not the pocket during the early years, the top-heavy trees that have blown over, and the plantations that have never "done" but remained stunted and unkindly, these are all witnesses to lack of judgment primarily.

These failures can in many cases be avoided, for it is quite possible to obtain first-rate material for all purposes required.

Let us see how the position stands with regard to apple trees. We know to-day that it is possible to attain a very considerable measure of control over the growth, cropping capabilities and even health of any given variety, merely by "working" it upon chosen root systems. We need no longer plant "a tree" and trust to luck that it may "do", we can plant a tree about which, other things being equal, we can make a very good guess that it will fill a certain space of ground and give fruit within a given number of years.

Of course soil conditions, pruning and manurial treatment, epidemics of pests and general accidents may modify these calculations, but in themselves these factors too largely rest in our own hands to control. To some extent, even, particular varietal partialities modify the general rules.

Out of a large number of apple stocks in commercial circulation, four have been selected as impressing especially marked characteristics upon the scion. Emphasis has been laid upon these groups and representative types in order to clear the ground and simplify the matter for nurserymen and growers. This does not mean necessarily that these are the only good stocks, or that better stocks may not be produced some day with still more desirable qualities. It means that in the present stage of scientific knowledge and economic practice, this measure of control is within reach of attainment.

The four groups referred to are as follows :—

(*a*) Very dwarfing—represented by Jaune de Metz Paradise (Malling Type IX.)
(*b*) Semi-dwarfing—represented by Doucin (Malling Type II.).
(*c*) Vigorous—represented by River's Broadleaved English Paradise (Malling Type I.).
(*d*) Very vigorous—represented by vegetatively reproduced " free " stocks, such as Malling Types XII., XIII., XVI., varieties as yet bearing no trade names and being at present only available in small quantities.

Now there is no such thing in fruit growing as a universal unalterable rule. So it is with these four groups. They have to be considered in the light of the variety worked upon them, the soil and climatic conditions in which they are going to be planted, and the subsequent treatment which they will receive. Let us say a qualifying word about each group :

(*a*) *Very Dwarfing.*—This type of stock gives a real dwarf tree which crops very early even when hard pruned. Even such varieties as Bramley's Seedling, Blenheim Orange and Belle de Boskoop begin to fruit in the second and third year and continue to bear heavy crops of large highly-coloured fruit. Trees on this stock are ideal for the small garden, the cordon and probably too for real dwarf " filler " apples to be planted to say eight to ten feet apart.

They are probably best used for choice dessert varieties, and even with moderately severe pruning will crop heavily. Of course on very light or very heavy soils, which naturally restrict growth, and with very weak scions, such as Stirling Castle or some of the heavy cropping " Codlins," such a stock would have a " stunting " effect and it should then only be used with caution outside the garden.

Trees on this stock will almost certainly require always to be kept staked, It is a curious fact that buyers are shy to purchase trees upon this stock, both because the growth is generally dwarfed (though sturdy), and because the root system is scanty. Buyers will go for the big tree even though they may really want dwarf fillers. They will not remember that there is a healthy dwarfness as well as a stunted dwarfness, and that if they want to bring their trees into early cropping, they can avoid the labour of root-pruning by buying trees upon roots that are naturally scanty.

(*b*) *Semi-Dwarfing.*—This group seems to afford a natural step above the rest. Though, generally speaking, trees upon this stock make bushes that

require planting at distances from twelve to twenty feet apart, according to soil conditions, they come into early bearing and serve as semi-permanent fillers for the vast majority of commercial varieties.

We regard it as the stock most adaptable for the moderate sized bush tree, but we do not recommend its use where certain scions are to be worked. Most of the Codlins, varieties like Stirling Castle and Lane's Prince Albert, are usually almost stunted by it, unless grown under somewhat exceptional conditions.

The heavier headed varieties worked upon this stock should be kept staked, or they are liable to blow about, and a very strong grower like Bramley Seedling is scarcely dwarfed at all by it.

On soils where " leaf scorch " is prevalent on apples, the *so-called* Improved Doucin Stock (Malling Type V.), which falls into this group, should be looked upon with suspicion, as we are accumulating definite evidence that some of these root systems notably devoid of fibre are associated with " scorch."

(*c*) *Vigorous.*—Trees upon this type of stock will, except on the lightest soils, and with the very weakest varieties, afford very large bush trees. Such varieties as Bramley Seedling, upon a medium soil, might well be planted at from twenty-four to thirty feet apart. The stock approaches a " free " stock and is generally more suitable for bush trees of such varieties as Stirling Castle and Lane's Prince Albert, and upon land tending to dwarf growth than the semi-dwarfing class. It also furnishes quite good sized half standard tree which should come into cropping earlier than on some of the very vigorous layered or seedling stocks.

Under most conditions it is well anchored and, after the first few years, may not require continued staking.

It will, of course, be realised that " garden " trees *can* be " made " upon all these three groups of stocks. They take little " making," except as regards form, upon Group A, but upon Groups B and C their size can be regulated and cropping effected by root prunings and transplanting.

Trees upon these types of stock are now readily obtainable in this country, which is certainly in the vanguard with regard to its production of fruit trees. All three types of stock have been known for a considerable period in this country, though Type IX. was seldom used, and individual tree raisers have their special likes and dislikes. The advantage of making full use of stock, however, has not been fully realised by the planter, and he has been apt to be content with " an apple tree," rather than an apple tree with particular possibilities in size and cropping.

(*d*) *Very Vigorous.*—This type of root system has always in the past been supplied by stocks raised from seed, commonly known as " crabs " and " free " stocks. These seedling stocks, of course, vary very considerably in their character,* and they reflect many of these variations markedly upon the scions.

* See Annual Report, Long Ashton Research Station, 1917.

Selected trees upon the best of these Seedlings undoubtedly make fine trees for standard orchard purposes, and, where bushes of weaker varieties are required, upon soil tending to restrict growth, they serve the purpose well. But in the use of seedling stocks as at present raised, it is not possible to maintain the same measure of certainty and control over the tree as is possible through the vegetatively raised stocks. Hence Long Ashton Research Station and East Malling have been seeking vegetatively raised " free " stocks which will give very vigorous orchard trees capable of a similar measure of control. It would appear that such stocks are not difficult to obtain, for Long Ashton, from amongst its collections of seedling " crabs," and East Malling, from its collections of so-called " Paradise," have picked out a number of very vigorous stocks, such as Bristol No. 5 or Malling Types XII., XIII. and XVI., which are easily raised by layers and yet produce large well anchored trees.

One or two of these stocks have taken the fancy of Nurserymen, and they are raising them in quantity for trial as " free " stocks. There is reason to suppose that they will be durable and serve the purpose well, but the public must wait patiently until sufficient have been produced. Moreover, time alone can reveal their ultimate size and length of life. Meanwhile, growers must choose selected trees upon good seedlings for orchard work.

Finally, it should be pointed out that it rests primarily with the grower to realise the enhanced value of these " controlled " trees upon guaranteed stocks. It is a costly process to maintain " stool " beds for layering, and to replace seedling by vegetatively raised stocks, and to eliminate the less desirable types, but if the grower creates the demand, the tree raisers will assuredly maintain the supply. The so-called cheap tree is nearly always a dear one. Only the tree over which forethought has been taken is the tree to serve the planter's purpose.

Plums

Our experimental work with Plum stocks is now beginning to yield some very definite indications, but unfortunately we are not, in all cases, in a position to press the recommendations we should like to base thereon, owing to actual circumstances. At the present time, it is probably true to say that, to a very large extent, the choice of Plum stocks used in commerce is largely governed by the availability of different varieties. For instance, in many localities where local Plums are grown upon their own roots, the suckers they supply are commonly used in the particular district as the main source of stock. On the other hand, those who specialise in the raising of Plum stocks have largely had to confine themselves to multiplying those varieties which lend themselves readily to vegetative reproduction, or which afford a plentiful supply of seed. In such circumstances, it is useless to recommend Growers to ask

for trees upon stocks which they are not likely to obtain in quantity for some years to come.

It seems better, therefore, for the purpose of this report, instead of chronicling the special successes of some of our newly selected stocks, to confine ourselves to remarks upon the suitability of those commonly available.

Probably if a census were to be taken of the older Plum trees in this country, a very large proportion of them would be found to be worked on one of two stocks: the Brussels or Common Plum. Both these stocks are very readily reproduced by layering, which to some extent undoubtedly accounts for their popularity.

Under our conditions, trees on Brussels have generally been quite mediocre in their performance, the stock appears to have a slightly dwarfing effect upon growth, but this does not show itself in accelerated early cropping. From the tree raiser's point of view the Brussels too has its disadvantages. In some years, and with some varieties, the number of buds which take is most disappointing. On the other hand, the stock is very plentiful, and there is so far no particular reason for condemning trees once they are established thereon, except that they " sucker " very freely.

The Common Plum, a speciality of the Surrey Nursery Districts, has much more decided effects upon the tree. Whilst dwarfing it far more distinctly, it brings it into early heavy bearing and, up to date, our Victorias worked on that stock head the list in cropping records. Different localities have variously named this stock as Hossgogg, Black Jack, etc., and claim for it that Plum trees worked thereon are much more resistant to Silver Leaf. Sufficient data is still wanting on this matter, but its effect upon the tree in giving a shortened sturdy growth and early crops of fruit, would seem to recommend it for a plum such as Victoria. Again, the tree raiser must use it with great care, since the buds of certain varieties, such as Czar, very frequently fail to take upon it.

Probably the next most widely distributed stock is the Myrobolan, often wrongly called Mirabella. Generally this stock has been raised from seed and the trees worked thereon vary somewhat markedly in consequence.

However, the general character of trees worked on Myrobolan is that of very vigorous growth, distinctly slow to come into cropping. From the tree raiser's point of view the stock gives both fine saleable trees and the buds of almost any variety take well upon them. From the grower's point of view it may be useful as a stock for very heavy cropping varieties, such as Czar or Purple Egg, to which additional vigour and some check to over-bearing are a distinct advantage.

If there is need for Myrobolan as a stock, it can be quite readily standardised by vegetative propagation. Our selected Myrobolan B. comes readily from both layers and wood cuttings.

Much the same criticisms might be made about the Brompton stock, though it is far less commonly used owing to the difficulty of its vegetative reproduction, for it is not raised from seed.

Two of the most robust and durable plantations of Czar plum that we know consist of trees on these two stocks.

Next, a word should be said about Mussel stocks. In connection with Plums it is probably hardly necessary to discuss the use of the Broadleaved or Shining Mussel Plum, since the supply of this stock is distinctly limited, and it is so much sought after for Peaches.

The so-called Common Mussel, looking for all the world like a Damson in both leaf and fruit characters, is the one in most wide circulation. Generally speaking, it gives a tree intermediate between the vigorous and partly dwarfed. Under our conditions it has been notably quick to bring the tree into cropping, and these records place it very high upon our list. Most varieties appear to take upon it, but we cannot help associating to some extent the leaf scorch which has appeared on some of our plums, such as Czar and Rivers' Early Prolific, with stock effect.

A word must be said about the St. Julien Stocks, and what is said about them would equally well apply to Black Damas. The vast majority of these stocks are raised from seed. and in many stock beds we have been able to pick out a large number of distinct seedlings, varying as widely as any of the named sorts we have hitherto been discussing. We have proceeded to propagate vegetatively, and test the utility of a number of these selections ; and some of them give promise of being of out-standing merit from many points of view, such as our Black Damas C. and St Julien A. But taking this seedling group of stocks, one may perhaps say that a high percentage of the trees worked thereon grow of intermediate size and become prolific croppers, though the variations exhibited are very great.

Finally, one word must be said about our results with the Pershore stock. Though this is one of those stocks already referred to, as of local use and limited in quantity (and it is impossible to deal with all these experimentally), the influence of the Pershore has been so outstanding in our trials that it must be especially mentioned. At one time it was suggested that the use of this stock might be a preventive to silver leaf. Under our conditions, we have no evidence at all to confirm this. But the Pershore stock has been an admirable " mother," all varieties of plum tested here growing well upon it. It has given trees of good vigorous growth, notably early to come into cropping, and it gives evidence of being a highly desirable stock. If the source of its supply was not so largely limited to a single district, and its methodical vegetative reproduction was not so uncertain, we should be very tempted to acclaim it as the best stock with which we have experimented up to date. We certainly hope that it may

be more widely used and more methodically propagated. The only disadvantage seems to be its none too firm anchorage on some soils.

PEARS.

In these days the majority of commercial Pears are only planted upon a Quince stock to serve as temporary " fillers ". It is, of course, now well known that whilst certain varieties such as Conference, Fertility and Durondeau will bud readily upon Quince, others such as Dr. Jules Guyôt and Williams' Bon Chretien are much less successful. However, it is not so generally realised that there are different varieties of Quince used as stocks, and that some of these stocks are very undesirable even for such a variety as Conference.

In the light of our present knowledge the true Angers Quince (Malling Type A), is the safest to ask for, though the Common Quince (Malling Type B) gives quite robust though slightly more dwarfed trees. We have, however, on several occasions, received from Continental sources a type of Quince, very spreading in habit and with leaves of a dark green colour, called by the name " de Fontenay " (Malling Type D). This variety of Quince is also not infrequently intermixed with the true Angers. Whatever its true name and origin, it is highly undesirable because it very frequently gives quite good maiden trees, of which only a very small percentage survive or make normal growth after the second year. Unfortunately, this manifestation of " incompatibility " is one which may easily pass unnoticed by the tree raiser, for the maiden tree looks healthy enough. Yet growers will suffer a high mortality amongst their young trees if they are not careful to insist on having them on guaranteed Angers stock.

A word must also be said about those varieties of Pear that do not take readily upon Quince direct. There are two alternatives, to buy these varieties upon a Pear stock or to buy them double worked upon Quince—that is, superimposed upon a variety that will grow well direct on Quince.

Now these " double-worked " trees are naturally more costly than the " single-worked " maidens, since, by the normal process of double grafting, they take twice as long to produce.

As a result, Growers often somewhat foolishly refuse to buy them, and so the supply is distinctly limited. Whilst we are unable as yet to give a detailed list of varieties requiring double working, and of suitable varieties for use as intermediates, we already have trees of Souvenir du Congres double-worked on Beurre d'Amanlis as intermediate doing well side by side with very poor trees of the same variety worked direct on Quince. Fortunately, this variety Beurre d'Amanlis is commonly used by nurserymen as an intermediate ; although it is still too soon to say that it suits all varieties double worked on it, early indications suggest that it also suits Dr. Jules and Marie Louise, both of which are unsatisfactory when worked direct on Quince.

The alternative is to plant these varieties directly upon Pear stock. Now, in the past, Pear stock, like " Free " or " Crab " Apple stocks, have been raised from seed. We have shown these Seedlings to be immensely variable, but we have also shown that it is possible to multiply individuals by vegetative methods (i.e., layering), and to-day we are raising some twenty or more selected varieties of Pear stocks, true to type, by these methods. The early indications upon young trees of Dr. Jules Guyôt, budded upon these different varieties of Pear root, give promise that this may be a very profitable line of investigation. The difference in the Maiden and two-year trees is remarkable. The use of " free " layered pear stocks, selected for their particular influence upon the tree may yet become a practical proposition. At present, we can only advise the planting of pears on chance seedlings with caution, and in exceptional cases, as for Standard purposes.

CHERRIES.

In the case of Cherry stocks we can as yet only advise planters to take such trees as they can get. The stocks now in use in the trade belong to three species of Cherry : the Sweet Cherry, Mazzard, Gean or Gaskain ; the Acid Cherry ; and the Mahaleb Cherry. We know as yet very little regarding the influence of these various stocks on the tree ; but we do know that they are almost always either raised from seed, or obtained as wildings from the woods, and that they show immense variation.

We have already found that many sweet cherry seedlings root readily from layers, and that stocks raised in this way show far greater uniformity than either seedlings or wildings. But it will inevitably be several years before layered sweet cherry stocks can be raised in large enough quantities for trade use, and meantime growers will have to plant trees on seedling or wilding stocks. Of the two the wildings are probably the less variable, owing to the fact that many of them are suckers rather than seedlings.

Part II

Physiology

Part II

PHYSIOLOGY.

In collaboration with the Plant Physiology Department of the Imperial College of Science and Technology.

By R. C. KNIGHT.

Programme of Research with Brief Progress Reports.

Water Relation of Stocks and Scions.

Transpiration.—Differences having been found in the influence of conditions upon the transpiration rates of leaves of different apple stocks, the investigation was extended to three apple varieties worked upon these stocks. It was found that although the stocks themselves exhibited differences, individuals of any one variety worked upon the different stocks did not show any differences in transpiration. It appears from this result that the explanation of the influence of stock upon scion is not to be found in transpiration differences.

Propagation.

Hard wood cutting trials have been continued and some progress has been made towards elucidation of the factors influencing rooting from cuttings. Four years' results indicate that callus formation is favoured by high soil-moisture content, whilst soil-aeration is an important factor in root formation. Further experiments are in progress to test these points.

Empirical attempts to increase rooting capacity by the introduction of various substances into the cuttings have failed to secure the good results which have formerly been obtained on several occasions, indicating that some uncontrolled factor has considerably influenced the rooting process. The relative effects of different treatments have, however, been constant throughout.

It may be noted that groups of seedling stocks, e.g., Myrobolan, St. Julien, and Black Damas Plums, show within each group, variations in readiness to root, as in many other characters. For example, as many as seventy per cent. of cuttings, of Myrobolan B. will root, whilst of the A, C, and D varieties, less than ten per cent. are usually obtained.

The propagation house has now been available over a full season and it is possible to indicate the first results obtained with soft wood cuttings. Preliminary experiments on the influence upon root production of :—

(i.) the " ripeness " of the cutting ;
(ii.) the time of year it is taken, and
(iii.) the medium in which it is planted ;

show that the optima of these factors are probably different for different varieties.

Individual results, which may be of immediate practical importance, may be noted :

The Mahaleb and some of the Austera cherries which are propagated from stools and layers only with considerable difficulty, and which have not yet been propagated at all from hard wood cuttings, may be readily rooted from soft wood cuttings.

FIELD EXPERIMENTS.

The first year's records from the second series of trees in which several buds of the same variety are worked on one root stock (see Annual Report, 1923, p. 87 (*a*)), have given the same indications as those from the first series of similar trees, in which, however, the unit was too small to give entirely reliable figures.

The introduction of two or three buds into a stock of Type I. or Type IX. resulted in the production of less new stem and more blossom buds per branch, and thus in both cases the number of blossom buds per 100 cms. of new stem was increased.

By this means the form of the " Type I." tree was slightly changed in the direction of the Type IX. form and the tendency of the " Type IX." tree to produce many blossom buds and a limited amount of vegetative growth is intensified.

This indicates that quantitative factors played a part, if a small one, in determining the type of tree produced, apart from the normal influence of root stock.

It should be emphasised that these remarks refer only to the early years of the life of the plant, and that in the first small series of trees dealt with, these purely quantitative influences were apparently ineffective in later life.

The first results from the double-worked trees with stocks as intermediates (Annual Report, 1924, p. 87 (c.)), show that the trees with Type IX. as an intermediate produced more blossom buds per unit of new stem, than the trees with Type I. as an intermediate. This occurred in both series, in one of which Type I. was the rootstock, and in the other Type IX.

Part III

Pathology

Part III

PATHOLOGY.

By H. WORMALD.

Programme of Research with Brief Progress Reports.

Brown Rot Diseases.

1. *Cross-infection Studies.* Strains of *Sclerotinia cinerea* have been isolated from various hosts, e.g., apple, pear, plum, cherry, peach and apricot. Material is being prepared for cross-inoculations and the inoculations will be carried out when greenhouse accommodation becomes available. The object here is to determine how far " Brown Rot " from one host can infect another.

2. *Distribution of the Brown Rot Fungi.* Cultures of Brown Rot fungi have been collected from various countries, and are being compared with a view to obtaining information as to the distribution of these fungi.

3. *Pear Blossom Wilt.* A blossom wilt of pear trees has been studied and inoculation experiments with the fungus isolated from diseased spurs have shown that the wilt is caused by *Sclerotinia cinerea.* The work is being continued to determine the relation between this and the blossom wilt of other fruit trees.

Crown-gall.

Field observations on crown-gall of apple stocks have been continued and the results recently published.* A résumé of these results appears on page 122.

Cultural studies of the organisms isolated from apple galls have been made and inoculation experiments on young apple stocks are being carried out in order to ascertain the relation between apple galls and the Crown-gall of other plants.

Preliminary attempts to isolate the crown-gall organism from the so-called " Root-knots " have given negative results and go in the direction of showing that the root-knots have no connection with crown-gall, but further experiments are necessary for confirmation.

Possible Effect of Root-Stock on Susceptibility of the Scion to Diseases.

1. Field observations suggested that certain stocks render the scions more susceptible to Apple Canker than others. Suitable young trees have been raised

* *Annals of Applied Biology*, XI., 278-291, October, 1924.

for the purpose of inoculations to test this point ; the fungus has been isolated to obtain pure cultures but the actual inoculations have not yet been carried out.

2. Field records are being made on the incidence of Leaf Scorch on various stock-trial plots, the results of which are already set out in the Pomological section.

3. In relation to plum stocks see Silver Leaf Disease, below.

4. Apple Mildew in relation to stock influence is being studied.

Silver Leaf Disease.

Field records of the incidence and progress of the Silver Leaf Disease upon trees on various known root-stocks have been taken and various remedial treatments have been tested in conjunction with Mr. F. T. Brooks ; the outstanding features are :—

(*a*) The very high percentage of natural recoveries in young trees of certain varieties such as the highly susceptible Czar.

(*b*) When, in the early stages, it was found possible to cut out silvered branches to unstained wood, this method of control proved successful.

In this work the pathologists have co-operated with the pomologists.

Raspberry Diseases.

These have hitherto received but little attention in this country, but the facts that several have appeared on the variety trials plot at this Station and have subsequently been found to be widely spread have shown the necessity for close observation. A preliminary survey of the diseases has been made by Mr. R. V. Harris at East Malling, and the observations have been extended to other plantations in England and in Scotland in order to obtain information relative to the distribution of the diseases and the extent of the damage caused.

The Ministry of Agriculture has made a special grant to this Station to enable Mr. Harris to continue his investigations.

The most serious of these diseases is a Wilt which produces symptoms similar to those characteristic of the Blue Stem disease of the black raspberry in America. This disease has received special attention ; a fungus (a species of *Verticillium*) found in diseased canes has been isolated, and inoculation experiments, carried out with pure cultures of the fungus, gave rise to the typical symptoms of the disease. It can be definitely stated therefore that this disease is caused by a fungus. A detailed account of this work, reprinted from the *Journal of Pomology*, appears on page 126.

A Cane Spot disease of raspberries is also being investigated. A fungus found on the spots appears to be identical with the organism found in America to be the cause of " Anthracnose " of raspberries.

In collaboration with the Pomological and Entomological departments observations have been continued on a disease of raspberries which is believed to be a form of " Mosaic " disease.

Hop Wilt.

A species of *Verticillium* has been found associated with a wilt of hop bines. Mr. Harris is also studying this disease in order to ascertain whether it bears any relation to the Wilt disease of raspberries.

Pear Canker.

Mr. Harris has made observations on an unusual form of pear canker. The results of these observations are given on page 135.

Hop Leaf-Spot.

The fungus (*Cercospora cantuariensis*) found associated with a leaf-spot of hops in 1922 (but has not been recorded since) has been isolated in pure culture, and inoculation experiments have given positive results showing that the fungus is the primary cause of the spots.

A Die-Back of Plum and Cherry Trees.

The diseases of plum and cherry trees referred to on page 113 are being studied with the object of determining whether the bacteria constantly found in the cankered areas are a primary cause of the disease. Bacteria have been isolated from various infected parts and preliminary inoculation experiments have yielded lesions in the case of plum shoots and leaves but further experiments are necessary before definite conclusions can be drawn.

Mulberry Bacterial Disease.

An investigation started at the South-Eastern Agricultural College, Wye, and continued at East Malling has shown that a disease of mulberry trees in Kent and Sussex is identical with a bacterial disease known as Mulberry " Blight " which occurs on the Continent, in America and in South Africa. The results of the investigation have been published,* and a résumé also appears in this Report (see page 120).

Bacterial Rot of Turnips.

An organism has been isolated from rotting turnips and inoculation experiments have been carried out with positive results. The organism proved to be *Bacillus carotovorus*.

* *Annals of Applied Biology*, XI., 169-174, July, 1924.

NOTES ON PLANT DISEASES IN 1924.

By H. WORMALD.

The following notes are not meant to be a systematic survey of the diseases of the district, such a survey being outside the scope of the work of this Research Station. They are based solely on observations made during 1924 (with two exceptions*) on the Station, on specimens sent in by correspondents asking advice, and on diseases seen on visits paid to growers. Some of the diseases mentioned were brought to the writer's notice by Mr. N. B. Bagenal, Horticultural Adviser for Kent, others by Mr. W. Goaring, Horticultural Superintendent for East Sussex.

Owing to the unusual rainfall the year generally was one very favourable for diseases caused by parasitic fungi. Certain diseases, which usually appear too late in the season to cause much damage, appeared early and were consequently more injurious ; this applied particularly to leaf diseases which in early attacks cause premature defoliation.

Potato Blight.

One result of the wet spring was that Potato Blight (*Phytophthora infestans*) appeared earlier than usual. On the Fruit Station it was first noticed on June 24th. On a few plants by this date all the leaves of some haulms were infected indicating that the disease had been already present on the leaves for some days.

Diseases associated with Botrytis spp.

The wet weather experienced almost throughout the summer was particularly favourable for attacks by *Botrytis*, and diseases caused by species of this genus were prevalent, assuming in some instances unusual forms. In addition to the usual types of disease, such as the Botrytis Die-back of Gooseberry and Currant bushes and Botrytis rot of lettuce, the following diseases were observed and deserve special mention.

(*a*) *On Apple Trees.* In April six young apple trees, of the Lord Derby variety, grown on the station, came under examination. Each one was found to have a cankered area at that region on the stem where the trees had been attached by means of bands of sacking. The diseased area in each case bore dense grey powdery tufts which proved to be the fructifications of a Botrytis

* See under "*Armillaria* root-rot" and under "Lavender Diseases". As there was no plant pathologist at this Station prior to October, 1923, no general report was presented for 1923 ; notes on these diseases (observed in 1923) are therefore included in the present report.

(probably *B. cinerea*). The fungus appeared to be the cause of the trouble, favoured probably by the moisture retained in the bands, but inoculation experiments to test this point have not yet been carried out.

(*b*) *On Hop Leaves.* Early in September young hop plants, raised from sets which had been planted the previous year on a neighbouring farm, were examined. Many of the leaves had diseased spots up to about half-an-inch in diameter; on the lower surface of the spots were fructifications of Botrytis (referred provisionally to *B. cinerea*) in every case examined.

(*c*) *On Onions.* (1) In the autumn two fields of onions were visited, one in North Kent, the other in the Swanley district, to examine a disease which caused a rot of many of the leaves. In one case the disease was in patches throughout the field, affecting the older leaves which were completely destroyed, but rarely killing whole plants. In the other case the disease was general over the whole field. The primary symptoms appear to be grey or whitish spots, for such spots were frequent on the younger leaves of those plants of which the older leaves were withered. In one case (field examined at the end of October), no fungal fructifications were seen on the leaves in the field, but on placing wilted leaves in a moist chamber numerous Botrytis fructifications appeared on them in about twenty-four hours; in the other case (seen early in December) the withered leaves were found covered with Botrytis in the field. Coarse hyphæ of the Botrytis type have been found in the grey spots of leaves not yet wilted, and the Botrytis has been isolated by transferring such spots to culture media. The Botrytis present on these diseased onions differs from *B. cinerea* in having conidia considerably larger (16-26 by 12-16 μ)* and it appears to be *B. parasitica* but comparison with a type culture of the latter has not yet been made. In some instances a bacterial rot was found to develop around the grey leaf-spots under laboratory conditions, suggesting that bacteria may also be concerned in the final rotting of the leaves. The relation that these two organisms, the Botrytis and the bacterium, bear to the disease has not yet been examined experimentally.

(2) Another disease of onions was brought to my notice by Mr. W. P. Wright. In this case the disease was a rot of the bulbs of onions grown in certain allotments in North Kent. A Botrytis was again found on the rotting parts, and on some specimens sclerotia were found. The conidia of this Botrytis are comparatively small (5-10 by 4-6μ) and the fungus is probably the conidial stage of what has been named *Sclerotinia bulborum*. The bulbs examined were from $1\frac{1}{2}$ to 3 inches in diameter and they were infected mostly at the upper end, though the root end was also rotting in some instances.

* The Greek letter μ is used to denote a unit of length known as a "micron", which is used for measuring microscopic objects. A micron is $\frac{1}{1000}$ of a millimetre or about $\frac{1}{25000}$ of an inch.

(*d*) *On Quinces.* Some of the quinces grown in the museum plot on the Station showed a brown rot on approaching maturity. In some cases *Monilia fructigena* developed over the diseased areas ; in others no fructifications were seen in the open but on placing the specimens in a moist chamber numerous Botrytis fructifications (*B. cinerea*) developed from the brown parts suggesting that the rot is caused by the fungus. The same fungus was also found associated with a similar rot on a specimen received from Sussex.

(*e*) *On Plum Cuttings.* A leaf-rot on " soft-wood " cuttings of plums in the propagating house on the Station was apparently caused by *B. cinerea* which made its appearance on affected leaves.

Brown-Rot Diseases.

In some orchards of sweet cherries blossom-wilt (*Sclerotinia cinerea*) was prevalent and owing to the continued wet weather the rot extended to the young fruit, so that not only were many of the flowers destroyed but where the fruit had actually set it later became affected.

On Morello cherries blossom-wilt was also severe and in this case resulted in infection of the young branches so that there was considerable die-back. In one plantation, to which a visit was paid, the damage could be traced to the fungus found on dead twigs which had been infected the previous year and had not been cut out.

Instances of blossom-wilt in apple trees (*Sclerotinia cinerea* forma *mali*) were also observed. One case was a plantation of Lord Derby trees in the neighbourhood of Maidstone that had had a serious attack of blossom-wilt during the summer of 1923, numerous cankers and dead spurs bearing the fungus were present on the trees during the following winter and the grower was advised to cut out these sources of infection. An attempt to carry out the advice was made but the work was done imperfectly and some dead spurs were overlooked with the result that blossom-wilt appeared again in 1924. It is important that the cutting out of infected parts should be done by careful skilled workmen who know what to look for. The best time for the operation is during the summer, when the wilted trusses indicate the location of the infected spurs.

" Wither-tip," similar in appearance to the condition common on young shoots of commercial varieties of plum trees, was found on a few stool shoots among the plum stocks of the Station. This disease is caused by *Sclerotinia cinerea* forma *pruni*. An unusual form of wither-tip was also observed on the variety stool-rows. Nearly every variety showed a number of wilted shoots during the summer and an examination of the underground portion of such shoots showed in every case a canker-like area that was evidently the cause of the wilting. As *Sclerotinia cinerea* was isolated from such cankers this fungus is probably the cause of this disease.

The same fungus also appeared, in the form of Monilia fructifications, on the leaves of "soft wood" plum cuttings in the propagating house, the disease killing a certain number of leaves and weakening the shoots. The general effect is similar to that associated with attacks of Botrytis under similar conditions (see page 112).

On the Research Station the fungus *Sclerotinia cinerea* has been found on two new hosts, viz.: on a young tree of *Prunus pumila* apparently killing the flowers and killing back the young branches, and on the flowers of a White Beam tree, *Pyrus Aria*, a specimen tree of which is in the museum plot.

Sclerotinia fructigena, the other common Brown Rot fungus, was prevalent in late summer; it was found causing fruit-rot of apples and quinces.

Die-Back of Plum and Cherry Trees.

A disease of plum and cherry trees causing a dying back of the branches in some cases, in others killing the trees outright has been prevalent in Kent and other counties. The disease resembles that which has been described as caused by *Diaporthe perniciosa*, but, in the case of a number of trees attacked at this Station, that fungus was rarely met with though other fungi were found on the cankers which appeared on the stems. It was noticed, however, that the margins of the lesions invariably contained dense masses of bacteria and it is thought that these bear some relation to the disease. On other fruit farms cases were observed where the branches were being killed back one by one, a condition also associated with bacterial masses at the margins of the cankered area.

Similarly in cherries the young trees are often killed outright but the branches are also attacked individually, and dead branches are common on older trees which become infected. Here again bacteria are massed at the margins of the cankers, though often the dead branches and stems bear fructifications of *Cytospora leucostoma*. In its general symptoms this disease of cherry trees is similar to a bacterial disease of cherry trees which have been described from Germany.*

A wilt of young plum shoots with bacteria massed in the lesions has been found on young plum trees on the Station associated in some cases with a dying back of the main stem. Whether this may have any connection with the die-back mentioned above has not yet been ascertained.

Leaf-spots, followed by "shot-holes" have been observed on plum and cherry trees. The young spots are invariably crowded with gelatinous masses of bacteria. This condition again is often associated with "die-back."

These diseases are under investigation.

* Aderhold, R., and Ruhland, W. Der Bakterienbrand der Kirschbaume, *Arb. a.d. Kaiserl, Biol. Anst. f. Land- und Forstwirt.* Bd. V., Heft 6, 1907.

CHERRY LEAF SCORCH. (*Gnomonia erythrostoma*)

This disease was general in 1923 as shown by the number of enquiries concerning it during the winter of 1923-24. With regard to varieties and this disease one grower wrote : " The Turks are quite clean and the Napoleons only slightly infected ; the Waterloos are by far the worst."*

Spraying experiments were carried out in collaboration with Mr. Bagenal in one orchard, in the spring of 1924 using, on some trees, Bordeaux Mixture before and after flowering, on others Lime-Sulphur ; a few trees were left unsprayed as controls, and from one tree all the dead leaves were stripped. The results were disappointing as all the trees became heavily infected. The summer of 1924 was very favourable for the disease, so that Bordeaux Mixture, which is known to be a useful wash for this disease, was found to be ineffective under the conditions which obtained. Even stripping the dead leaves was not successful with sources of infection around, under the abnormal weather conditions.

" SMALL-LEAF " DISEASE OF CHERRY TREES.

A disease of cherry trees which is causing considerable loss in some orchards in North Kent is one characterised by the small size of the leaves as compared with healthy trees. The diseased trees have, in consequence, a reduced leaf area and this diminished density of foliage is a striking feature of the early stages of the disease. At later stages branches die back and the trees become doomed. In some orchards the affected trees are scattered, but in one orchard to which a visit was paid, one portion (about three-quarters of the whole) showed the trouble while another portion showed no signs of the disease and on enquiry it transpired that there had been this distinction between the two areas for a considerable number of years. This seems to indicate that the trouble is not of an infectious nature but is probably due to unfavourable soil conditions. What these conditions are it is impossible to say at present.

APPLE SCAB AND PEAR SCAB (*Venturia inaequalis* and *V. pirina*)

were unusually prevalent in 1924. On pears serious infections were seen on the flowers themselves before they had actually set into fruit. In the case of certain specimens examined it was found that such infested flowers were in close proximity to scab pustules on the previous year's wood, these pustules evidently being the cause of the early infection of the flowers. These observations show the necessity for cutting out infected twigs during the winter and also how important it is to give a pre-blossoming spray on trees known to be infested with scab.

* It may be of interest to note in this connection that Prof. E. S. Salmon wrote, in 1906, "In several large orchards which have been affected I have seen Turks and Napoleons practically free from the disease, while Waterloos have proved very susceptible."—(See *Jour. S.E. Agric. Coll.*, No. 15. July, 1906).

Pear Canker.

A canker of the current year's shoots on cordon pear trees at West Malling was observed in September, infection starting at the nodes before leaf-fall. A further note on this unusual form of infection is given on page 135.

A Canker of Nursery Stock.

Certain budded apple stocks on the Fruit Station developed cankers round the point of insertion of the bud. Mycelium was found in the discoloured wood vessels of the stock, suggesting infection by a fungus, but the actual cause of the cankers has not been determined.

Root-rot of Fruit Trees.

(*a*) *Armillaria mellea.* In October, 1923, an old orchard of apple trees near East Malling was examined: in one part of the orchard were gaps showing that some trees had been removed, and around these gaps were several trees with numerous fructifications of the Honey Fungus (*Armillaria mellea*, a common parasite of forest trees) growing out from the base of the trees. It was evident that the gaps represented trees that had been previously infected and that the disease was extending in the neighbourhood. The fungal fructifications were shedding spores freely as was shown by the white dust on the grass around, the white dust consisting of myriads of spores.

About the same time a similar condition was seen in the case of cob-nut trees in the same neighbourhood; here again were many fructifications of *Armillaria mellea* round the bases of the trees.

In May, 1924, rhizomorphs of the same fungus were found associated with a root disease of young pear trees in the Swanley district.

(*b*) *Rœsleria hypogœa* was found on roots of young pear trees, variety Reine des Poires, (grafted on pear stocks) from two localities, the trees, however, having been obtained from the same nursery; the fungus has also been found on a young damson tree and on a plum tree on the Research Station. To what extent this fungus is directly responsible for loss to young fruit trees in this country is not known. On the Continent it is generally assumed that it is able to attack vines, and recent work in America shows that under certain conditions the fungus may become a wound parasite.

An Apple Rot.

While examining diseased apples that were being sorted out soon after they were picked it was found that, while many of them were infected with the Brown Rot fungus *Sclerotinia fructigena*, in a few cases a species of *Glœosporium* was present on the rotting spots. It was found that the rot could be re-produced, with the subsequent development of the Glœosporium fructifications, by

inoculating spores of the fungus into apples by means of punctures but work with pure cultures has not yet been attempted.

Quince Diseases.

Observations were made on the incidence of diseases of quinces on the type trees grown in the " Museum " plot on the Station. The leaf and fruit blotch, caused by *Fabræa maculata* (=*Entomosporium maculatum*) was very common on some varieties, all or nearly all the leaves and fruit on these trees being infected: pronounced premature defoliation occurred on such trees. Some of the trees were almost free from this disease and there is good evidence therefore that certain varieties show definite resistance to this disease as compared with others, but further observations are necessary for confirmation of this.

Rots caused by *Sclerotinia fructigena* and *Botrytis cinerea* appeared as the fruit approached maturity, the rots in some cases causing a premature fall.

Fruit spots with which were associated two species of *Phoma* were also observed but the injury caused was negligible.

Raspberry Diseases.

The variety plots of raspberries on the Station have shown a number of diseases during the past season, including mild attacks of Mildew (*Sphærotheca humuli*) and Rust (*Phragmidium rubi-idæi*). The more serious diseases were (1) a Wilt Disease caused by a species of *Verticillium*, (2) a disease which superficially resembles the Anthracnose of raspberries in America, but the fungus described as causing the disease in that country has not yet been found on our own material,* and (3) a disease which appears to be a form of Mosaic. These diseases are under observation, the wilt receiving particular attention as it is responsible for the death of a high percentage of canes in some varieties.

The characteristic symptoms of the wilt disease are given elsewhere in this Report (see p. 126).

Diseases of Currants and Gooseberries.

The leaf-spot fungus *Pseudopeziza* (*Glœosporium*) *ribis* appeared early in the season on Currants and Gooseberries, causing premature defoliation. In one case it was associated with a serious leaf-fall from gooseberry bushes towards the end of June. Leaves of the Black Currant infected with the rust fungus *Cronartium ribicola* were received from various localities and this disease appears to have been very prevalent during 1924. A species of *Diplodia* was found on a young Black Currant shoot of a potted plant in the greenhouse, the fungus apparently killing back the shoot; the fungus was isolated and inoculations

* While this article was in the press both stages (ascigerous and conidial) of the Anthracnose fungus (*Plectodiscella veneta*) have been found on raspberry canes grown in this country.

carried out to ascertain whether it was parasitic, but up to the present the results have been negative.

Gooseberry leaves received from Sussex in September showed, in one sample, the leaf-spot fungus ; in another case the leaves were mostly infected with the European Gooseberry Mildew (*Microsphæra grossulariæ*). On some of the leaves were spots about quarter inch in diameter, silver grey in colour and bordered by a dark line ; some of the spots bore a species of *Phyllosticta*, conforming to descriptions of *P. grossulariæ*, while others had a species of *Ascochyta*. These two fungi were apparently parasitic but were causing no material damage.

Walnut Blotch.

During July Walnuts were received from a garden in North Kent, the young green fruits showing black blotches causing conspicuous disfigurement. The lesions in general appearance resembled those described in America for a bacterial disease but attempts to isolate a bacterium from the spots of the specimens examined gave negative results. On a visit paid to the garden several large walnut trees were found with the disease, and on one tree about half of the young fruits were disfigured. It was seen that the leaves were generally infected by the common leaf-spot fungus *Marssonina juglandis* (=*Gnomonia leptostyla*) and on further examination fructifications of the same fungus were found on some of the black lesions of the fruit. It would seem that this fungus, which is generally described as affecting the leaves only, also infects the fruit.

As this fungus passes the winter on the fallen leaves, these should, where practicable, be raked together and burnt when the trees have been infected during the summer ; this should not be found impossible in the case of isolated trees growing in private gardens.

Diseases of the Hop.

Hop Powdery Mildew (*Sphærotheca humuli*) was fairly general during the season but it is now usually kept under control by the use of flowers of sulphur and calls for no special mention.

A slight attack of the Downy Mildew* (*Pseudoperonospora humuli*) appeared on the hops on the Station. It was at first thought that it had been introduced on hop sets, but observations made during the summer suggest that the disease is of old standing on " wild " hops, for hop plants found growing on the railway embankment adjoining the Research Station (but at some distance from the cultivated plants showing the disease) had many leaves with the characteristic spots.

A wilt disease of hops was observed in a hop garden near Tonbridge ; this disease caused a wilting of the leaves and withering of the bines. About

* This disease is under investigation by Prof. E. S. Salmon and Mr. W. M. Ware at the South Eastern Agricultural College, Wye ; a description of the disease and the fungus causing it will be found in the *Journal of the Ministry of Agriculture*, Vol. XXXI, No. 12. March, 1924.

forty per cent. of the hills showed one or more wilted bines. A species of *Verticillium* was isolated from infected bines suggesting that the fungus is the cause of the disease, but inoculation experiments to obtain confirmation of this have not yet been carried out.

A *Botrytis* leaf-spot of hops has already been referred to (see p. 111).

Lettuce Diseases.

The "Ring Spot" or "Rust" disease* caused by *Marssonina panattoniana* : is still found to be doing considerable damage on fields of lettuce in the Swanley district. The disease is often seen in isolated patches in drilled plots and also in the fields to which plants are transplanted from the plots, suggesting that the disease arises, in these cases, on single plants and then spreads from these to others around. An instance of how transplanting may transmit the disease in this way was observed in the late autumn. Seed had been drilled in plots between rows of apple trees. When the seedlings were old enough some were transplanted to another field. During the operation the grower noticed that certain patches of about a square yard in area in the drilled plots were seriously affected, so seedlings were not taken actually from such patches though others were taken from the immediate neighbourhood for planting up. The fact that such patches occurred in the plots was an indication that it would have been wiser not to transplant from the plots at all, and a visit to the field where the seedlings had been planted up showed that some infected individuals had actually been transplanted, thus forming centres for infection in the new field.

Botrytis was found associated with a soft rot in some specimens and the Downy Mildew (*Bremia lactucæ*) was generally distributed in the fields but the chief cause of loss in the crop was the *Marssonina*.

Lavender Diseases.

In October, 1923, an inquiry was received at East Malling respecting a disease of lavender bushes known as "shab". The enquiry was the outcome of a visit that had been paid by Mr. A. H. Hoare, Horticultural Inspector to the Ministry of Agriculture, and the writer to a grower of lavender in Surrey. This disease is one which produces a rapid dying out of the bushes and soon causes a field to become unprofitable. The disease was found to be associated with the presence of a fungus, *Phoma lavandulæ* on the stems† and another fungus, *Septoria lavandulæ* on the leaves. The former was evidently the chief cause of the trouble but the latter was responsible for considerable spotting and

* A description of this disease will be found in the *Journal of the Ministry of Agriculture*, Vol. XXX., No. 2. May, 1923.

† This phase of the disease has been described by Dr. W. B. Brierley. See *Bull. Misc. Inform.* Roy. Bot. Gardens, Kew. No. 5, 1916, pp. 113-131.

withering of the leaves. From the method generally adopted in propagating lavender (by splitting a bush into several portions and transplanting them) it would appear highly probable that the disease is transmitted from one field to another by propagation from infected bushes. Attempts should be made by growers to raise disease free stocks by striking cuttings selected from healthy bushes, and planting out in fields that have not previously grown lavender.

MULBERRY BACTERIAL "BLIGHT."*

By H. WORMALD.

A DISEASE of mulberry trees (suspected at the time to be identical with one known to occur on the Continent, in America and in South Africa) first came to my notice as having appeared in this country in 1914 when mulberry leaves showing black spots were sent to Wye College from Bognor. In the following year leaves showing similar spots were received from a nursery in Kent where the disease was causing considerable damage to young trees.

A microscopic examination showed that the diseased spots contained numerous bacteria. By the usual laboratory cultural methods a white bacterium was isolated from one of the spots and inoculation experiments were carried out with it on mulberry leaves and shoots. From these experiments it was found that the disease could be reproduced by introducing the bacterium into leaves or shoots by means of punctures, and an organism was re-isolated from one of these induced spots. Later it was found that this re-isolated organism was identical in its morphological and physiological characters with the one used in the inoculations ; thus proof was obtained that the disease was caused by the bacterium isolated.

It was not until recently, however, that the identity of this organism has been completely established. Cultural experiments with the organism (started at Wye College and continued at East Malling) have given results similar to those obtained by Dr. Erwin F. Smith in America and Dr. Ethel M. Doidge in South Africa with the Mulberry " Blight " organism. This, together with the positive results obtained from the inoculation experiments, shows that the disease in this country is the same as that known abroad as Mulberry Bacterial " Blight."

The disease is recognised by small black angular spots on the leaves ; black spots also occur on the shoots themselves, killing them back in some cases. Individual spots are usually about one-twentieth of an inch in diameter but they are often very numerous so that a considerable portion of the leaf surface is destroyed. Around the spots the leaf-tissue assumes a yellowish colour, and leaves so affected usually fall early in the season.

In the nursery the disease was particularly severe on young trees during the first year after they were removed from the stool-beds. It was also found in the stool-beds themselves, and it is highly probably that layers already infected were planted out, so giving rise to infected trees. Older well-established

* A more detailed account of this disease (with reference to its occurence in Britain) and the organism causing it has been published in *The Annals of Applied Biology*, Vol. XI. No. 2, July, 1924, pp. 169-174.

trees have been seen with the disease and these may in some cases serve as sources of infection for young stock planted up in the vicinity.

The organism causing this disease is a rod-shaped bacterium measuring about 3 by 1 μ* ; under favourable conditions in liquid culture media it is actively motile, swimming about by means of from one to six flagella situated at one end of the rod. It is known as *Bacterium mori.*

Another disease of mulberry trees, and one which may be confused with the bacterial disease here mentioned, is due to a fungus *Gibberella moricola.* This causes cankers followed by the wilting and death of the young shoots and branches ; in this case the leaves are not spotted unless the bacterial " Blight " is also present.

The bacterial disease is undoubtedly a most troublesome one when it appears on mulberry stocks in the nursery and it is essential that disease-free layers only should be used for propagation. All seriously infected stools should be dug up and burnt.

* See footnote p. 111.

FIELD OBSERVATIONS ON THE CROWN-GALL OF NURSERY STOCKS.*

By H. WORMALD and N. H. GRUBB.

Galls on nursery stocks are a frequent source of annoyance to nurserymen for, although the galls in many cases apparently affect the general health of the trees but little if at all, trees or stocks badly galled cannot be sent out.

Plant galls are brought about by various agencies. Many of them are produced by insects, but in such cases there is generally no difficulty in locating the parasites. Galls of the type referred to in this article are, on the other hand, tumours in which there are no obvious parasites. Even microscopic examination has not revealed the presence of an organism in naturally developing galls, and for a long time the true cause was in doubt although many theories have been put forward to explain their development. In 1907, however, two American workers† furnished proof that the so-called Crown-gall of Chrysanthemums was caused by a bacterium which they named *Bacterium tumefaciens*. Their results have been confirmed by other investigators (in this country by Robinson and Walkden‡) and it is now generally recognised that Crown-gall is caused by *Bacterium tumefaciens*.

It is not to be assumed that all galls in which there is no visible parasite are caused by this organism. Cell proliferation resulting in galls may be induced by various mechanical and chemical agencies and the only ultimate criterion that a gall is caused by a parasite is to isolate the organism from the gall and then to induce similar galls by inoculations with pure cultures of that organism.

In the case of apple galls in this country an organism closely related to *B. tumefaciens* has been isolated from the galls and preliminary inoculation experiments on apple stocks have given positive results in a few cases ; it may be assumed then that these galls fall into line with the Crown-gall of America.

Our own observations have been made mostly on the galls found on layered apple stocks, grafted or ungrafted at the end of two or three years after their removal from the stool bed. In addition to galls on such stocks we have seen similar outgrowths (collected from various sources in this country) on " Crab " stocks, layered pear stocks and young pear trees, layered hawthorn stocks, plum and cherry trees, raspberry, loganberry, mangel, beetroot, melon, hop and hollyhock.

* A more complete account of these observations has been published in the *Annals of Applied Biology*, Vol. XI., Nos. 3 and 4. (October, 1924), pp. 278-291.

† Smith, E. F., and Townsend, C. O. A plant tumour of bacterial origin. *Science*, N.S., XXV. (April, 1907), 671-3.

‡ *Annals of Botany*, XXXVII., No. 146 (April, 1923), 299-324.

On layered apple stocks the galls usually grow out from wounds, particularly those made when removing the layer-shoots from the layer. Such galls developing from the lower end of the stocks after planting out we refer to as "basal galls"; galls may also arise on the sides of the stem near ground level and on the roots. On stocks raised from layers or from stools, then, the galls are mostly basal. On seedling trees on the other hand they are generally at the collar, at or near ground level. In America, too, the galls on nursery stocks are mostly situated near ground level, often a result of the method ("bench grafting") of working the stocks practised in that country.

In size the galls vary considerably; on the stocks raised from layers the basal galls frequently measured 2 to 3 inches in diameter. On a pear layer a gall was found measuring 4 in. by 3 in. The largest gall we have seen was one sent to us from Huntingdonshire; it was found on a root of a Victoria plum tree and was 6 inches long by 5 inches wide, while its weight was 1 lb. 13 ozs. From observations made on some two-year-old seedling apple trees examined by us at East Malling it was found that the gall itself may sometimes weigh as much as 40 per cent. of the total weight of the young tree.

The galls increase considerably in the course of a year. In an experiment carried out at this Station galls on young apple trees were measured during the winter and the trees then planted up. In the following winter the trees were lifted and the galls again measured. In one case a gall $2\frac{1}{8}$ inches in diameter increased to 3 inches during the year and in another the increase was from $1\frac{3}{4}$ to $2\frac{1}{2}$ inches in diameter.

Certain apple stocks produce galls more readily than others. From observations made in the East Malling stocks it appears that Type VII. and No. 51 are the most susceptible, whilst among the least susceptible are Type I. (the "Broad-leaf" Paradise) and Type VI ("Nonsuch" Paradise). Type II. (Doucin) has shown an intermediate degree of susceptibility.

Of the apple stocks raised at East Malling not one has proved to be wholly immune to crown-gall.

Some evidence has been obtained that the size of the galls on the stocks is influenced to some extent by the variety of scion grafted on the stock. Thus stocks worked with Lord Derby, Early Victoria and Lane's Prince Albert produced galls more readily than those worked with Bramley's Seedling, Bismarck, Newton Wonder or Stirling Castle.

Until quite recently it has been generally assumed that Crown-gall is a serious disease, and in America where much attention has been given to it, stringent regulations have been in force to prevent the importation from abroad of nursery stocks infected with Crown-gall and the transporting of galled trees from one State to another. Some American observers, however, maintained that the disease caused little material damage, at any rate after the trees are

planted up in their permanent quarters, and a careful examination of large numbers of trees by investigators in that country has lent support to such statements, as shown by two recent papers bearing on this point.*

Observations made at East Malling afford further evidence that the galls have often no appreciable deleterious effect on the growth and general health of the trees subsequent to planting up. Records have been made of the length of new growth and the number of fruit buds year by year on certain trees of Bramley's Seedling and Worcester Pearmain grafted on known stocks (Types III. and VII.) some of the trees bearing galls at the time of planting, the others being free from galls. The trees have been under observation for five years and up to the present no difference in health or vigour has been detected between the trees bearing galls and those without galls.

The effect of the galls on young trees in the nursery has not yet been determined and can only be ascertained by an examination of stocks of similar origin and vigour, some free from the disease, others infected. It would seem, however, that the galls must have some retarding effect on the general development of the young trees since the cells composing the galls contain numerous starch grains, a form of food which, presumably, would have been used by the tree to produce normal growth if infection had not taken place. Our field observations on large numbers of layered stocks have not yet, however, supplied any evidence that the galls have any harmful effect on young nursery stocks. In fact, in any one batch of stocks it is frequently noticed that the trees with the largest galls are the most vigorous, or perhaps it would be better expressed to say that the most vigorous trees tend to produce the largest galls, for experimental work with other plants e.g., mangels,† has shown that well-nourished plants produce larger galls than ill-nourished ones.

No means are known at present whereby infection by Crown-gall can be satisfactorily controlled by methods involving soil treatment.‡ The object of the nurseryman is to produce vigorous stocks, and the soil conditions necessary for this would appear to be those favouring gall-development. On the other hand some evidence has been obtained that care in handling the stocks will reduce the amount of infection and also that it is possible so to protect the cut surfaces that infection of such wounds is reduced. These results based on experiments

* Green, L. and *Melhus*, I. E. The effect of crown-gall upon a young apple orchard. *Res. Bull., No.* 50. *Agric. Exp. Sta. Iowa College of Agric.*, March, 1919, pp. 147-176.
Reddick, D. and Stewart, V. B. Crown-gall of Apple and Peach. *Mem.* 73 *Cornell Univ. Agric. Exp. Sta.*, March, 1924, 19 pp.

† Levine, M. "Studies on Plant Cancers," III. *Amer. Jour. Bot.*, VIII., No. 10, December, 1921, pp. 507-525.

‡ Since this was written a paper has been published by Sherbakoff in which evidence is offered suggesting that an application of "inoculated" Sulphur to the soil may be effective in controlling crown-gall (See *Phytopathology*. Vol xv, p. 105, Feb. 1925).

carried out at East Malling on stocks raised from layers and stools, have been published elsewhere.* Summarised they are as follows :—

(1) Cutting the shoots from the layers or stools with a knife is preferable to tearing them off, as the clean cut surface is less favourable for gall development than a rough tear.

(2) Covering the cut surface at the lower end of the stocks with grafting wax or Stockholm tar reduces the number and size of the basal galls.

(3) Galls on the stem above the base, and root-galls, may be largely prevented by careful handling and planting, so as to avoid unnecessary injuries.

* See *Gardeners' Chronicle*, April, 22nd, 1922, pp. 198.

THE BLUE STRIPE WILT OF THE RASPBERRY.*

By R. V. HARRIS.

I. Introduction.

A disease of the cultivated Raspberry (*Rubus Idæus L.*), hitherto unrecorded for this country, was brought to the notice of the present writer in the winter of 1923-24. All the varieties (collected from various sources) grown in the trial plots at the East Malling Research Station showed at least a trace of the disease, while some varieties were affected to such a degree that the results of the trials were being seriously impaired and an investigation of the disease was imperative.

The wood and pith of diseased canes collected during the winter were found to be infested with delicate fungal hyphæ and particles of the wood and pith transferred to agar plates yielded with marked purity and regularity cultures of a fungus which was identified as a species of *Verticillium*. Later (in spring and early summer) other organisms were isolated from diseased fruiting canes, but no one organism appeared with the constancy shown by this species of *Verticillium* which was isolated from many varieties of Raspberry and over a considerable period of time. That this fungus is the cause of the disease was shown by the inoculation of seedling plants from plate cultures of the *Verticillium* when the characteristic symptoms of the disease (described below) were induced under adequately controlled conditions.

No fructifications of the fungus have been observed on diseased canes and roots under field conditions, but they were readily produced under moist artificial conditions in the laboratory. In the winter, however, minute black resting bodies (microsclerotia) were observed in large numbers embedded in the tissues of the bark of infected canes of several varieties, which, on transfer to agar plates gave rise to cultures of a *Verticillium* similar to that isolated from the diseased wood and pith. These sclerotia, therefore, probably function as reproductive bodies.

This disease, with respect to its effect on the cane and on the fruit, has many points of resemblance with the "Blue Stem" disease of the Black Raspberry (*Rubus occidentalis L.*), described by Lawrence (5), a striking feature in both cases being the appearance of a blue colouration of the cane which sometimes takes the form of a stripe. Lawrence refers the suspected parasite to the genus *Acrostalagmus* Corda, and proposes a new species *Acrostalagmus caulophagus*. More recently Carpenter (2), concludes that this species "must be regarded as belonging to the genus *Verticillium*." Lawrence appears to be the only worker who has

* Reprinted from Journal of Pomology and Horticultural Science, Vol. IV., Nos. 3 & 4.

published, in any detail, an account of the " Blue Stem " disease as occurring in America, though brief references to the disease have appeared from time to time (1, 3, 4, 6, 7). Lawrence isolated what is probably the causal organism, but carried out no inoculation experiments for confirmation.

II. Field Observations.

The chief points of interest arising from observations extending over one year, carried out over the collection of varieties on the trial plots at the East Malling Research Station will now be dealt with in some detail in order to provide sufficient data for the recognition of the disease in the field.

(1) *Symptoms on the Fruiting Canes.*

The only indication of the disease during the winter was the presence of dead canes with shrivelled ill-developed buds. The diseased condition was thrown into strong relief, however, when the canes came into leaf in the spring. The dead canes then became very conspicuous and, in addition, some canes were seen to be partially affected by the disease from the failure of a proportion of buds on the canes to burst. These dead buds were found to occupy nodes lying in the same vertical line, thus destroying the radial symmetry of the cane. On sectioning such canes a discoloured strip of wood was found corresponding to the nodes bearing the dead buds, the remainder of the wood being normally green. The proportion of wood thus found affected in the spring, varied greatly.

As the leaves appeared and the lateral fruiting branches grew out, some canes were conspicuous for the dwarf character of their leaves and the poor development of their fruiting laterals. In some of these cases the cane lived to produce under-sized, woody, tasteless fruit, and in others the leaves soon became yellow and withered, and the cane died before the fruit was matured. Other fruiting canes were noted which did not show symptoms of disease until some time after they had come into leaf. There was great variation in the stage of development of the fruiting canes at which the first symptoms of disease were shown, and in the rapidity and extent of the subsequent progress of the disease in the cane. Thus some canes, apparently healthy as the leaves unfolded, soon afterwards showed symptoms of attack and in a short time their leaves became yellow and withered. In other cases the symptoms did not appear until the fruit approached maturity; in these cases the leaves became prematurely discoloured and withered, followed by a withering of the fruit and the death of the canes.

The distribution of diseased fruiting canes in the row varied. In some cases only a small proportion of canes or only one cane of a stool showed symptoms of

disease but often all the canes of a single stool would show the disease to a greater or less degree. Some cases were noted in which all the canes of a stool were affected to an extreme degree, the canes being dwarfed and ill-developed in every way, and producing no fruit or small, woody, discoloured, tasteless fruit. Stools with all the fruiting canes dead were by no means uncommon. Such severely infected stools generally produced but little new cane and "spawn."

(2) *Symptoms on the New Canes.*

The most characteristic symptoms of the disease are those which appear on the new canes (or current year's canes). These symptoms, however, do not appear until comparatively late in the season. Thus until just before cropping time stools were observed whose fruiting canes showed symptoms of disease, but whose new canes appeared normal.

The first case of symptoms of disease in the new canes was observed at the end of June on a variety very susceptible to the Wilt (Red Antwerp A.*). A stool was noted with three canes, all very dwarfed. One was a fruiting cane, and showed discoloured and wilted leaves, and such fruit as was present was very under-developed. The remaining two were new canes and were conspicuous on account of a dark blue discolouration of the cane; in one case there was a distinct blue stripe extending upwards from ground level, while in the other, this blue colouration was at first dense in patches and thinned out in places. The continuity of the discolouration from ground level, could, however, be traced in both cases. On both canes the leaves had wilted and withered, apparently quite suddenly, for they were still greenish in colour, although dry. On examination in the laboratory, the outer wood vessels of these new canes were seen to be infested with delicate mycelium characteristic of the *Verticillium*, and most of the hyphæ appeared to be extending in an upward direction rather than laterally. There were no hyphæ in the pith. On transferring sections made at various points on these canes to agar plates the *Verticillium* grew out in a pure condition.

This was an early case of what became quite general as the season progressed, and similar symptoms were observed in a large number of different varieties. From every new cane examined, showing the blue stripe symptom, the *Verticillium* was isolated, generally in a pure condition. In the autumn, however, it became necessary to distinguish the blue stripe as a symptom of the wilt disease, from the ripening colouration of the cane. The blue stripe was observed to work up the cane from ground level and was continuous, whereas change of colour due to ripening, often took place irregularly in patches. The limits of the stripe were very sharply defined and usually ran in a vertical line,

* The classification followed here is that of Grubb in "Commercial Raspberries and their Classification," Journal of Pomology. Vol. III., No. 1. November, 1922.

FIG. 1.

A "new cane" (var. Lloyd George), photographed Sept. 4th, showing initial wilt symptoms, i.e., collapsing and "striping" of lower leaves.

FIG. 2.

One of the lower leaves of the cane in Fig. 1, showing withering of interveinal tissues and curling of leaflets. Note, in this case, that the withering is more advanced on the right of the midrib.

so that there was a sharp contrast which was not obliterated even when the ripening colour had appeared as well. In a few varieties such as *Bath's Perfection*, the stripe was dark blue-brown in colour, but in most cases the blue colour was unmistakable. In fact, this blue stripe effect was found to be the most reliable symptom for the diagnosis of the disease in the field and suggested as a descriptive name the " Blue Stripe Wilt of the Raspberry."* On sectioning new canes with the blue stripe, a sector of the wood corresponding to the stripe on the surface was invariably seen to be more or less discoloured. Many of these canes, particularly those showing the blue-stripe earliest in the season, were, later, completely girdled, all of the wood becoming discoloured, and the whole cane conspicuous for its dark blue colour. Such canes soon died.

The effect of the disease on the leaf of the new canes was not as a rule so sudden and complete as in the particular case described above, but could often be observed long before the " stripe " appeared on the cane. In fact the characteristic leaf symptom was often the first sign of infection in a new cane. The lower leaves of the cane were always the first to be affected. The tissues of the lamina lying midway between the main veins became yellow or red-brown, the colour varying in different varieties. This colour change became increasingly accentuated and finally these interveinal tissues withered, the tissues immediately around the main veins retaining their green colour for a considerable time, so that the leaf had a characteristic striped appearance (Plate VI, Fig. 1).

A point which distinguished this phenomenon from autumn discolouration was that often only a part of the leaf was striped. Thus leaves were observed in which one half of the terminal leaflet (limited by the midrib) was striped, and also the entire lateral leaflet on the same side of the stalk, whilst the other half of the terminal leaflet and the corresponding lateral leaflet were quite green and normal (Plate VI, Fig. 2). Later, the effect spread by degrees to these unaffected parts. The striping of the leaves was often accompanied by a withering and upward curling of the margin or part of the margin of affected leaflets and ultimately such leaves fell prematurely, the leaflets generally being cast independently and the petiole remaining attached to the cane for some time. The symptom described above forms one of the most striking features of the disease. The under surface of the leaves, being nearly white, shows up, on these leaves with the upward curled margin, in clear contrast to the dark, striped upper surface.

The terminal tuft of leaves was invariably the last to be affected and often survived the rest of the leaves for a considerable time, so that the spectacle of new canes denuded of their leaves with the exception of the tuft of latest formed leaves was quite common. Cases were also noted where the leaves arising from

* This as a descriptive name is perhaps preferable to Lawrence's term " Blue Stem Disease," since in some varieties of our red raspberries a general bluish colouration appears on the new canes towards the end of the season in the absence of any evidence of the Wilt Disease.

nodes in the same vertical line were affected in advance of the others, a condition obviously corresponding to that observed on those fruiting canes whose buds were killed in vertical lines. The appearance of the blue stripe (which, from results obtained from cultural work, indicated the extension of the fungus into the aerial parts of the cane), often did not take place till all the leaves had shown the stripe and wilting symptoms and had been cast. Sometimes, however, it appeared at an early stage and the rapid death of the affected cane took place.

Numbers of canes showing initial symptoms of the disease (i.e., leaf striping), were labelled and kept under observation. The majority of these canes eventually showed the later symptom of the disease and the *Verticillium* was isolated from a number of them. In some cases this appearance of the *Verticillium* in the cane with the accompanying discolouration of the wood vessels was delayed until late Autumn and early Winter.

It will be seen from these observations on the new canes, that, as with the fruiting canes, there was great variation in the rapidity with which the disease symptoms followed each other in different canes, and in the severity of attack. The final killing of the whole or part of individual canes, generally, though not always, took place in late Autumn or early Winter.

(3) *The Distribution of the Disease and the Seriousness of Attack.*

About a hundred varieties of Raspberry in the collection at the East Malling Research Station have been examined from time to time, and notes made as to the incidence of the disease. In no case was a variety found completely free from the disease, but the severity of attack varied greatly with the variety. In some varieties it was negligible but in many, among which were varieties of commercial importance, the effect of the disease was considerable, both on the fruiting canes and on the new canes. In such varieties it was noted that the severely diseased stools were usually adjacent to one another in a row which consequently had a "patchy" appearance.

Among the varieties most seriously affected at East Malling the following might be mentioned:—

Bath's Perfection.
Red Antwerp B.
Prior's Prolific.
Mitchell's Seedling.
Red Antwerp A.*
Baumforth A.
Baumforth B.
Reader's Perfection.

* Black Antwerp A. although almost indistinguishable systematically from Red Antwerp A. is one of the least seriously attacked varieties here.

FIG. 1.

Pot B, of inoculation experiment thirty-five days after inoculation of plant on the left.

FIG. 2.

Plants shown in Fig. 1 but five days later: lower leaves of inoculated plant withered, terminal leaves drooping.

FIG. 1.

Plants as in Plate VII., Fig. 2, but nine days later: lower leaves of inoculated plant fallen, and terminal leaves withering.

FIG. 2.

Stem of inoculated plant as shown in Plate VII., Fig. 1 (nat. size): point of inoculation protected by cotton wool, above; dark stripes downwards and upwards from this point; petioles collapsing and becoming striped.

To obtain a numerical measure of the severity of attack on the new canes in one instance, counts of diseased and healthy new canes were made in September over fifty consecutive stools of a row of the variety *Bath's Perfection*, which under our cultivation conditions is very susceptible to the disease. The proportion of the total new canes showing definite symptoms of disease was 40 per cent.

There is reason to believe that the disease is widespread for its characteristic symptoms have been noted in other localities. The *Verticillium* has also been isolated from specimen canes sent from Surrey and Sussex.

A more extensive survey of the incidence of the disease on different varieties and in different localities has been planned for the future, and the writer would be interested to hear from growers and others who have noted the disease and would welcome specimens and information relating to varieties affected and extent of injury caused.

III. Inoculation Experiment.

An attempt to induce the symptoms of the disease by artificial inoculation of healthy plants with the fungus suspected of causing the disease, was made at the end of July, 1924.

Seedling plants (consisting of one slender leafed cane) raised from seed obtained the previous summer from "selfed" flowers of the *Lloyd George* variety, were employed for this experiment. These were grown in three pots, three plants in one pot, and two in each of the others. One plant in each pot was kept as a control and the remainder inoculated, each at a point above and below soil level. There were thus four plants inoculated and three controls.

The inoculations were carried out by introducing into small holes bored in the stem, mycelium from agar plate cultures of the *Verticillium* isolated from infected canes by the direct transference of diseased tissue to the plate.

The observations made on the progress of the disease in the inoculated seedlings, are summarised in the accompanying table in which the three pots are referred to as A, B, and C respectively. From this table it will be seen that, of the four seedlings inoculated, all developed, sooner or later, symptoms of disease closely corresponding to the symptoms observed in the field, and three of the four were completely killed. From these three seedlings the *Verticillium* was re-isolated. All the controls remained healthy.

The rapid progress of the disease in the inoculated plant in pot B, is illustrated in Plate VII, Figs. 1 and 2, and Plate VIII, Fig. 1. Plate VII, Fig. 1 was taken on the day following that on which the symptoms of disease were first detected (thirty-four days after inoculation), and Plate VII, Fig. 2 and Plate VIII, Fig. 1 at intervals of five and nine days respectively. Plate VIII, Fig. 2 shows part of the cane of the inoculated plant as shown in Plate VII, Fig. 1, and shows

the upper point of inoculation protected by cotton wool, the blue stripe extending upwards and downwards from this point, and the semi-detached petioles in its neighbourhood, also striped.

Although the number of plants available for inoculation was small, the results as seen in the table and in the figures are sufficiently striking to warrant the conclusion that the species of *Verticillium* isolated with such constancy from diseased canes and used in these inoculations is the parasite causing the disease described in this paper.

IV. Aim and Scope of Work in Progress.

At this stage not enough is known of the life-history and physiology of parasitism of the fungus in its relation to the raspberry to enable reliable methods of control to be recommended.*

Field observation work is being continued with special reference to the relation between severity of attack, the variety of raspberry attacked, methods of cultivation, and locality conditions.

In addition, experimental plots have been planned to facilitate the study of the relative importance of different sources of infection in their relation to the incidence and spread of the disease, also the degree of dissemination of the disease by various methods employed for the propagation of the raspberry, and the possibility of producing clean stock for planting up.

Meanwhile, as it has been proved that the disease is due to a fungus present in the underground system and in the canes of infected stools, growers and nurserymen are advised to raise their stocks from stools which show no symptoms of this disease.

SUMMARY.

1. A disease of the cultivated Raspberry causing a wilting and death of the canes, progressing from below upwards, is described, and the nature and extent of its damage to the crop discussed.

2. Cultural work with diseased material resulted in the isolation of a fungus of the genus *Verticillium*, with marked constancy, from affected stools of many susceptible varieties.

3. An inoculation experiment carried out under controlled conditions on seedling plants, using plate cultures of the species of *Verticillium* isolated from diseased canes, was successful in inducing the disease with its characteristic symptoms as observed in the field.

4. It is proposed for reasons stated to designate the disease by the descriptive title " The Blue Stripe Wilt " of the Raspberry.

* Further research in this disease is being carried out by the writer under a grant, made by the Ministry of Agriculture and Fisheries, to the East Malling Research Station, for research in Raspberry Diseases.

5. Temporary control measures are recommended pending further research along lines which are indicated.

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(6) Rankin, W. H., Running-out of Raspberries. *New York Agric. Exp. Stn., N.Y.* Circ. 67 (1923).

(7) Rankin, W. H., Raspberry Mosaic and Blue Stem. *New York State Agric. Exp. Stn., Geneva, N.Y.* Circ. 75. (1924).

Table summarising observations on Raspberry Seedlings inoculated July 30th, 1924.

	Pot A.			Pot B. (moist conditions).		Pot C. (under bell-jar).	
Date of observation.	Plant 1.	2. Control.	3.	1.	2. Control.	1.	2. Control.
September 3.	No disease symptoms.	No disease symptoms.	No disease symptoms.	Blue-stripe on cane; leaves yellowing, lower leaves detached, upper leaves healthy. (See Pl. VII, Fig. 1).	No disease symptoms.	Dark-stripe on cane. Some leaves detached, others drooping. Upper leaves healthy.	No disease symptoms.
September 5.	Do.	Do.	Do.	Blue-stripe rapidly extending and girdling. Sectorial yellowing and some withering of leaves.	Do.	Stripe extending slowly.	Do.
September 8.	Lower leaves yellowing.	No disease symptoms. Leaves all green.	Lower leaves yellowing.	As above, rapid withering of leaves. (See Pl. VII, Fig. 2).	Do.	Yellowing of leaves, Stripe extending.	Do.
September 17.	Lower leaves yellowing and withering sectorially. Lowest leaves detached. Blue-stripe on two petioles.*	No disease symptoms. A few leaves showing autumnal discolouration.	As in Plant 1.	All except terminal two leaves detached. Whole cane dark blue. (See Pl. VIII, Fig. 1).	Do. As in control of Pot A.	Stripe extending. All leaves except uppermost yellowing and becoming detached.	Do. As in control of Pot A.
October 29.	Blue-stripe has appeared on cane. All leaves detached except terminal four.	No disease symptoms. Normal leaf fall beginning.	Leaves still wilting. No blue-stripe.	Plant completely dead.†	Do. As in control of Pot A.	All leaves except uppermost three are detached. Sector of dead wood in cane.†	Do. As in control of Pot A.
November.	Cane completely dead. Shoot arising at ground level still living.†	No disease symptoms. Wood green.	Wood of cane still green.		Do. As in control of Pot A.		Do. As in control of Pot A.

Fusarium stage of the fungus *Nectria galligena*, the cause of Apple and Pear Canker, developed on the blackened bases of the leaves stalks and on the cankered areas of the shoots around affected leaves. Cases were observed where the pustules appeared simultaneously on the blackened leaf base of an attacked leaf and on the cankered area of the stem around that leaf base.

A number of current year's shoots bearing withered leaves with blackened bases but with no sign of cankered areas on the shoot were marked in place on the tree and kept under observation till leaf fall. On a number of these shoots cankers developed, later, around the scars of the infected leaves, and in February, 1925, produced pustules of spores resembling those that developed under laboratory conditions in the previous autumn.

As was mentioned above, the symptoms of the disease on the leaves, as described, were associated with scab spots on the leaf and leaf stalk, but whether previous infection by the scab fungus is necessary for the canker fungus to gain an entrance in this particular form of infection is not known. Infection of the canker fungus through leaf scars and scab lesions has been described by Wiltshire,* but the infection of current year's shoots through the bases of leaves still on the tree appears to have been unrecorded hitherto.

* Wiltshire, S. P. "Studies on the Apple Canker Fungus. I., "Leaf Scar Infection, *Annals of Applied Biology*, VIII., pp. 182-192. II., "Cankers Infection of Apple Trees through Scab Wounds." *Annals of Applied Biology*, IX., pp. 275-281.

Part IV

Entomology

Part IV

ENTOMOLOGY.

Programme of Research with Brief Progress Reports.

By A. M. MASSEE.

The Study of Resistance of Various Apple Stocks to Attacks of Certain Insect Pests.

(1) *Resistance to Green Apple Aphis* (*Aphis pomi*, De Geer).

During the past season the plants previously selected for their outstanding susceptibility or resistance have been multiplied vegetatively in sufficiently large quantities for a continuation of the direct infections in 1925.

(2) *Resistance to Woolly Aphis* (*Eriosoma lanigera*, Haus).

As is stated elsewhere in this report, this work was unavoidably interrupted. Previous to his departure for Long Ashton, Mr. L. N. Staniland, of the Imperial College of Science, was able to carry the investigation one step further by infecting the fresh material supplied and suggested by East Malling. This material was planned to show how far the Aphis might establish itself on composite trees, e.g., those with resistant roots and susceptible scions and *vice versa*. A report will doubtless appear on this aspect of the work in due course.

A considerable amount of fresh material has been worked up during the year for a continuation of the investigation at East Malling.

Several batches of Mr. Crane's Seedlings, Doucin (Type II.) crossed with Northern Spy are ready for systematic testing. Some of them have proved to be very ready rooting, and if any of them prove to be resistant to Woolly Aphis, they may provide a new race of resistant root stocks.

Black Currant Gall Mite.

(1) *Study of Life History.*

A detailed study of the life history of the currant bud mite under local conditions has revealed several factors which have apparently been unrecorded hitherto. Amongst these observations are certain facts relating to the period of exposure of the mites, the methods of their distribution, etc., which may well affect the economic measures for their control.

A paper is now in course of preparation upon these points for publication during the coming year.

(2) *Susceptibility of Black Currant Seedlings to Mite Attack.*

A series of seedlings of known parentage have been subjected to direct Mite infection. Up to the present results show that all seedlings infected are more or less susceptible to attack. It should be pointed out, however, that although it has been possible to establish Mites on any particular plant, the degree of attack and manifestations of the pest differ on individual seedlings.

(3) *Treatment of Mite Infected Cuttings.*

Although fairly definite indications of the superiority over other treatments of the immersion of cuttings in cold water for a given period have been obtained two years consecutively, it is proposed to continue these trials for yet another season before publishing the results.

(4) *Control of Big Bud in the Field.*

A fourth season's data greatly strengthens the results hitherto obtained and published last year by Mr. H. M. Tydeman ; that lime sulphur applied at winter strength, in the spring, proves to be far more effective in the control of Bud Mite, than the other methods of control tried in the experiment. Unsprayed rows are adjacent to those which are lime sulphured and this winter (1924-1925) the contrast has been most striking to the eye. The details of these results will be found on page 158.

Systematic Study of Whole Group of Gall Mites (*Eriophyidæ*).

Out of this work has developed a systematic study of the whole group of Gall Mites, since it has become obvious that even upon the plants like the Black Currant, species of mites are commonly to be found which have hitherto been unrecorded. One such (*Phyllocoptes masseei*, Nalepa), closely allied to the familiar species, has this year been recorded and described at East Malling and may prove to be of considerable economic importance.

It was sent for identification to Dr. Alfred Nalepa, of Vienna, who confirmed that it was a new species, named it as above, and made an official description of it in " Marcellia." V., XXI., pp. 95-96, 1924.

The Leaf and Bud Mite of Raspberry.

The common occurrence of this Mite (*Eriophyes gracilis*, Nalepa), in Raspberry plantations, has been mentioned elsewhere. [*The Journal of Pomology* Vol. IV., Part 1, pp. 25-27, 1924].

Field research is in progress to ascertain their effect on the Raspberry, during the summer months, whilst the mite is actually feeding on the leaves.

"Reversion" in Black Currants.

Investigation into Causes and Transmission.

In this work the Pomological, Physiological, and Entomological Staff are all co-operating from their different standpoints.

(1) Field experiments designed to test the possibilities of transmission of the trouble by grafting and "inarching" were initiated in 1922 and were repeated on a much more extensive scale in 1923. Observations have shown that whenever the combination of healthy and "reverted" individuals succeeded, in the second season the originally healthy individual became definitely reverted.

(2) Another series of experiments was designed in which various means were adopted to modify the normal cycle of growth. For example, by the removal of all well developed buds from the plants, buds, which would not otherwise have developed in the current season, were forced into immediate growth. These universally manifested temporary symptoms of "Revision" from which they subsequently recovered.

(3) *Attempts have been made to upset the Metabolism of the normal Plant.* It has not been found possible to induce the symptoms of "Reversion" in healthy plants by the method of "stem feeding." Various solutions have been used, including carbohydrate-nitrates, weak acids and alkali and the liquid obtained from root pressure exudation of reverted plants. In no case was any characteristic reversion observed in the experimental plants except when "temporary" reversion appeared in shoots from buds forced into new growth late in the season as the result of damage to main growths.

(4) From 1921 onwards healthy Black Currant Bushes have been directly infected with Mite on a considerable scale, and there is considerable weight of evidence that Mites do transmit "Reversion." A very high percentage of previously healthy Currant Seedlings showed "Reversion" after direct Mite infection. A full account of all this work is now being prepared for publication.

The Insect Fauna of Raspberries and possible Relation to "Mosaic" Diseases.

The Insect Fauna of Raspberries is being studied on the variety plots at East Malling. It has been claimed in America that certain insects are carriers of "Mosaic" disease of Raspberries, and that they aid the spread of the disease from plant to plant. These particular American species of insects have not yet been found in this country. However Raspberry Canes have been directly infected with insects closely allied to the American species, so far with only negative results.

Both the Pomological and Pathological Staff are co-operating in this investigational work upon Raspberry "Mosaics."

Apple Blossom Weevil Control.

Investigations concerning this pest which were continued in the spring of 1924 have now terminated. A full report of this work has been published in the *Journal of Pomology and Horticultural Science*, Vol. IV., Part 1, and is reprinted on page 145.

PRELIMINARY FIELD TRIALS OF TAR DISTILLATE WASHES.

By A. M. MASSEE.

Throughout 1923 constant enquiries were received here regarding the safety and comparative efficiency of the various tar-distillate washes on the market. It was decided, in co-operation with Dr. Goodwin of the South Eastern Agricultural College, and the County Horticultural Advisor, and representatives of the Technical Committee of the Chamber of Horticulture, to test some of the better known brands. Dr. Goodwin agreed to procure a tar-distillate wash of known consistency for comparison with the proprietary brands. It is obvious, that if such a wash proved as effective as the proprietary brands it would be a great advance, since the formula for its manufacture could be divulged, and a uniform composition assured.

It was realised that the testing of insecticidal spray fluids on severed shoots in the laboratory made possible the taking of very accurate comparative observations *under those conditions*. However, it was felt that these conditions were so unlike those in the field, in that both spray fluid and eggs were protected from the action of the weather, and the eggs kept under unnatural conditions, that, it was decided to carry out the initial experiment in the field. It was determined as far as possible to make an actual inventory of insect eggs both on sprayed and unsprayed trees. The difficulties encountered in this attempt will be described below.

A plot containing 224 bush apple trees of Bramley's Seedling and a "codlin" apple, probably Early Rivers, was kindly put at our disposal by Mr. W. H. Tolhurst, of Ditton Court Farm. The plot itself was chosen because insect eggs proved to be less scarce than on our own trees.

The plot was divided into eleven sections, of which three were left untreated. On the other sections three well known proprietary brands, and Dr. Goodwin's standard wash, were applied, each in duplicate.

Early in the autumn notes were made on all the trees individually, both as to their general condition, and regarding the insect injury of the previous Summer. Finally, the detailed inventory was made of the number and kind of insect eggs observed on each tree. In order to mark the position of the eggs on the shoots and spurs, small tag labels were at first tied just beneath them. This method proved inadequate, for on dull days it was not possible to detect the eggs already marked. To overcome this difficulty the position of each egg was finally indicated by inserting a small brass pin just below it. This survey showed that the eggs of the Winter Moth (*Cheimatobia brumata*) the green

Apple Aphis (*Aphis pomi*) and the Apple Sucker (*Psylla mali*) were the most common. The eggs of an un-identified mite were also very abundant.

Unfortunately, even on these specially chosen trees insect eggs were extremely scarce and difficult to find except in very favourable conditions of light. They very soon became still scarcer, a second post spray survey showing that eggs carefully marked had frequently disappeared, owing possibly in part to the ravages of a predacious mite.

The washes were applied on 8th February 1924 by means of a petrol power sprayer.

Precautions were taken to see that each individual spray was applied at the same force, but it was not possible to apply the same quantity of wash to each tree, as the trees varied greatly in size.

All trees, however, received a thorough covering. The using strength of all the tar-distillate washes was $7\frac{1}{2}$ gallons of stock solution, to $92\frac{1}{2}$ gallons of water, as then recommended by the makers of the insecticides.

As far as the actual spreading qualities of the washes were concerned, it can be said that, without exception, they covered the trees quite evenly. Similarly, all washes mixed satisfactorily, and could not be considered at all troublesome to handle. One brand left some sediment in the tank, after standing awhile.

A few days after the application of the sprays, a detailed examination was again made on all trees. One striking factor was the general appearance of sprayed trees compared with the untreated "controls". The algæ and lichens which had been so common on all trees, were completely destroyed on sprayed trees, giving them a thoroughly healthy appearance. This striking cleansing effect was general. Many trees had much loose bark on the trunks, this readily peeled off after the washes had been on for a few days. Weeds and rough grass under the trees were apparently killed by the spray, the damage however, in the case of the grass was only temporary. Lastly, there was no apparent spray damage to any part of the trees subsequently.

Owing to the scarceness of eggs (already referred to) during the Winter of 1923-1924, and to the subsequent disappearance of many of them, it was not possible to obtain definite conclusions as to the insecticidal value of the various tar-distillate washes.

However, after all the labels had been removed, the plot was inspected when in full leaf by a member of Staff who did not know its arrangement. In two out of three cases the untreated plots were picked out from the general appear- of the leaves, which seemed to indicate more severe caterpillar attack.

These investigations are being continued for a further season, both with a view to testing further these and other winter washes and of improving our methods of field technique.

THE CONTROL OF THE APPLE BLOSSOM WEEVIL.*

(*Anthonomus pomorum* L., Curt.)

By A. M. MASSEE.

As far back as 1920 the damage done by the Apple Blossom Weevil upon the young trees, set apart for the Apple-pruning experiments, became sufficiently widespread to endanger the general results of these trials. Despite the fact that East Malling had at that time the assistance of no entomologist possible methods of controlling the pest in the field were initiated. It was decided to test certain more or less commonly recommended methods of control, and to analyse, as far as time would permit, the movements of the insect on the trees. The original programme was drawn up by Mr. R. G. Hatton, who was assisted in the execution by Miss K. P. Worsley. Such data as were collected during the years 1921 and 1922, were handed over to the writer of this present account, who became associated with this work in 1922, and took over the entire charge of it from 1923 onwards. At the beginning of 1921, a series of experiments were started on a plantation of seven-year-old bush Apple trees, used as a Pruning plot. For convenience, the various methods of control tested may be dealt with under the following headings;

(1) The value of hens, as being greedy devourers of many insects, including caterpillars, and some beetles.

(2) The jarring of the trees to dislodge the insects and the subsequent trapping of them on their return by grease-banding the trees.

(3) The use of Lime-wash in Spring, just before the blossom opens, or the application of an arsenical spray at the same period. The former wash was claimed to smother or impede the weevil, the latter to poison them direct whilst they are preparing a cavity for the reception of their eggs.

(4) The possibilities of various methods of trapping the weevil, such as banding.

(1) The Use of Hens.

Poultry enthusiasts often claimed that hens, running about in plantations, were a valuable asset in the control of the Apple Blossom Weevil. Moreover,

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Theobald[1] presented some evidence in support of this claim. After an examination of the crop and gizzard of poultry he had on two occasions found the remains of weevil, principally *Otiorrhynchus picipes*. F., but also *Anthonomus pomorum*, L., Curtis. An experiment was therefore started, to find out if this method of control could be relied upon to reduce the pest under plantation conditions. A series of thirty-two Lane's Prince Albert bush-apple trees was selected. This plot was divided into two equal parts. One half was entirely enclosed by wire netting, to confine the hens, yet to enable them to run about at will. The other half of the plot was used as the " control " or untreated plot. The hens used were twelve White Leghorn pullets. It should be mentioned here that the experiments commenced in the Spring when the weevils were plentiful on the trees. All trees, including those on the " control " half were grease-banded, the band being placed as high up on trunk as possible. The bands were thus out of reach of the poultry, and it was hoped that if the weevil proceeded from the ground by way of the trunk to the branches, these bands might give some measure of the numbers going up by this method on both plots. Finally, in order to dislodge the weevils from the branches, and give the poultry a chance of attacking them, the trees on both plots were severely shaken. This operation was carried out repeatedly on all trees. The grease-bands were left on the trees until September. The number of insects caught on the bands may be summarised as follows :—

	Apple Blossom Weevil.	*Leaf Eating Weevil.*	*Caterpillars.*
Plot with hens	13	39	11
Plots without hens ..	29	2,591	27

It will be seen that the number of Apple Blossom Weevils caught on the bands was very small ; in fact, the number does not suggest that grease-banding is of much economic importance in the control of this pest. This fact is further emphasised in a later experiment. In the Spring, following the penning of the poultry, the number of capped blossoms per tree, on the two plots, was counted. Whilst sixteen per cent. of the blossom on the trees under which hens had had free run was " capped," ten per cent. of the blossom on the " control " trees was " capped."

The pullets were generally sparingly fed and on several occasions considerable quantities of Apple Blossom Weevils, collected, off the jarred trees in the plot, were given to them as food ; with a single exception, they did not take readily to these weevils as food, but after one or two pecks they ignored them, and went on scratching for other animal life in the soil. On the other hand, evidence is available to show that the same pullets acted as a very effective

control for another species of weevil, i.e., the Leaf-Eating Weevil (*Phyllobius oblongus*, Linn.). The figures already quoted lead irresistibly to this conclusion. As Theobald[1] has pointed out, poultry evidently have marked preferences and cannot be relied upon indiscriminately to control every species of weevil. On the other hand, growers might do well to remember that there is evidence that poultry help to control at least two species, the Leaf-Eating Weevil *Phyllobius oblongus*, Linn.) and, according to Theobald,[1] the Raspberry Weevil *Otiorrhynchus picipes*, F.) which does so much harm to " the buds and grafts of Apple and Pear."

2. The Jarring and Grease-Banding of the Trees.

There is apparently a common belief that these weevils, especially the females, rarely if ever use their wings. As recently as 1920, P. J. Fryer[2] states, " The females are winged, but usually prefer to crawl up the trees." It was agreed that if this assumption was true, the weevils should be trapped on their way up the trunk by effective grease bands. Though as far back as 1909 Theobald[3] stated that " There does not seem sufficient evidence, however, to justify grease-banding for this pest," it was decided to try and collect some definite evidence upon the point. Some trees were banded on April 1st and 2nd ; these trees were then jarred, or shaken severely in the hope of dislodging the weevils in order to catch them on their return journey to the branches. Other trees in the same series were merely banded without being jarred, and a third series were left unbanded. A negligible quantity of Apple Blossom Weevil were actually caught on any of the bands, and an examination of the " capped " blossoms on the three series of trees in the subsequent Spring gave no result in favour of the banding, as the following figures show :—

Lanes' Prince Albert and Gladstone Apples.

Jarred and banded	8 trees.	12.5 per cent. " capped " blossom.
Banded (only)	8 trees.	11 per cent. " capped " blossom.
Untouched controls	4 trees.	12 per cent. " capped " blossom.

It has been noticed that the mere jarring of a tree, to dislodge the weevils, is of little value ; as a matter of fact, it has been found that a severe shaking is necessary in order to make the weevils fall. It appears that it is a general thing for this particular species to make a hole right through a leaf with its rostrum, then should it desire to keep on the leaf, it is able to do so by placing its rostrum through the hole in the leaf, thus enabling it to get a firm hold. In fact, they may commonly be seen attached to the leaf by this method.

3. Lime Washing and Arsenical Sprays.

Between March 24th and 30th, 1921, the whole of the Apple pruning plot at East Malling was sprayed with a Lime wash. The lime was put on at the rate of 112 lbs. quicklime to the 100 gallons of water. The lime was slaked slowly on the headland, and applied with its natural heat thickly before blossoming. No weevils were observed on the trees at the time of spraying, though it was afterwards proved that they must have been present in quantity. Careful observations were made upon the trees following the application of the lime. Many of the weevils were actually observed to be laying their eggs in the normal manner, others were shaken in quantity from the trees and were closely examined in the laboratory. "Their wing cases were often tightly sealed, their legs showed balls of lime on the joints, . . . such weevils thoroughly coated in lime, were still fully active and able to perform their normal duties a good three weeks or a month after they had received the dressing."[4]

Lime-coated weevils were seen as late as the end of June over three months after the application of the lime. There was no evidence of death caused by lime-spraying, though the spraying had been exceptionally well done. In a test of sprays, under laboratory conditions, Miles[5] found the killing efficiency of Lime Wash, 43 per cent. as against 100 per cent., where Paraffin Emulsion was used, but apparently these results were not sufficiently promising to extend the application of Lime Wash as a field trial. It can only be said that, under the conditions at East Malling, where the trees are young and without much loose bark, Lime Wash as a control for Apple Blossom Weevil proved anything but effective. This does not mean that Lime Washing may not be a commercial proposition as a general late dormant cleansing wash where trees are old, neglected or abounding in crevices suitable for hibernation.

On April 13th an Arsenate of Lead Wash was applied to certain apple trees which had already received the Lime Wash. The object was to spray the trusses with a poison, just before the blossom opened, to test whether it was possible to poison the weevils, whilst they were eating their way into the unopened flowers, previous to oviposition. White sheets were placed under the trees before spraying, and were left on the ground for forty-eight hours, to determine the number of weevils which dropped from the trees. Observations showed that weevils did not drop on to the cloths in any numbers, but that they remained alive on the trees. The percentage of "capped" blossoms on these sprayed trees did not differ from that upon a similar number of "control" trees. On the other hand, the writer of this report has made close observations upon the habits of the Apple Blossom Weevil, and is quite satisfied that these weevils do feed upon the epidermal surfaces of apple leaves to a considerable extent both before and after oviposition. It is therefore at present not quite clear

why an efficient application of Lead Arsenate fails to afford a considerable measure of control.

4. Trapping Methods: Sacking Bands used as a Means of Collecting Weevils when they go into Hibernation.

Trapping, as a method of controlling various weevils, has been recommended from time to time, although the particular method chiefly investigated at East Malling does not appear to have been commonly advocated in this country. Lees[6], in 1920, mentioned that trapping might "prove the easiest way on a commercial scale," and referred to this method of control being used in the Tyrol. Investigations on these lines do not seem to have been seriously followed up, and our attention to the real possibilities herein was drawn to the matter in 1920 by an accident. In July of that year it happened that the old sacking bands put round the stems of some of our apple trees, to prevent the rubbing of the stakes, were being removed, when Mr. C. A. Duffield, of the Entomological Department of the S.E.A. College, Wye, was visiting us. He started examining the bands to see what insect life they contained and it was found that a large number of Apple Blossom Weevil was present. This suggested the idea of placing strips of old sacking round Apple trees for the purpose of catching weevils when they seek hibernation. A preliminary experiment was commenced, to determine the most suitable time for putting on and taking off the bands. This investigation to shed light upon the habits of the weevil was begun in May, 1921, and was continued up to December, 1922. A plot of sixty-four bush Apple trees, Allington Pippin and Worcester Permain, was chosen on account of the large numbers of "capped" blossoms that had been noticed in the previous season. These trees were all banded at approximately fifteen inches from ground level. Every tree was examined weekly, the weevils contained were removed and counted, and these bands were then replaced. So that a complete record of the hibernating weevils might be obtained, white sheets were placed round the base of the trees before the removal of each band, in order that any weevils dropping to the ground might be noted. It was encouraging from a practical point of view, to find that few weevils actually dropped on the sheets, and that the great majority stuck to the bands, though a few remained on the trunks as is mentioned later.

The examination of the bands was continued for eighty-two consecutive weeks in order to get the annual cycle[8]. It is interesting to note that approximately fifty per cent. of the weevils caught, a total of 1,099, was found on each variety of apple, an aspect of the question which will be referred to again later. The following figures give the results :—

TABLE I.

NUMBER OF WEEVILS COLLECTED IN BANDS EACH MONTH FROM MAY, 1921—APRIL, 1922.

		No. of Weevils in 64 Bands.	*Monthly % of Total Trapped.*
1921	May	136	12.3
1921	June	229	20.8
1921	July	233	21.2
1921	August	114	10.3
1921	September	49	4.4
1921	October	105	9.5
1921	November	57	5.1
1921	December	19	1.7
1922	January	21	1.9
1922	February	35	3.1
1922	March	63	5.7
1922	April	38	3.4

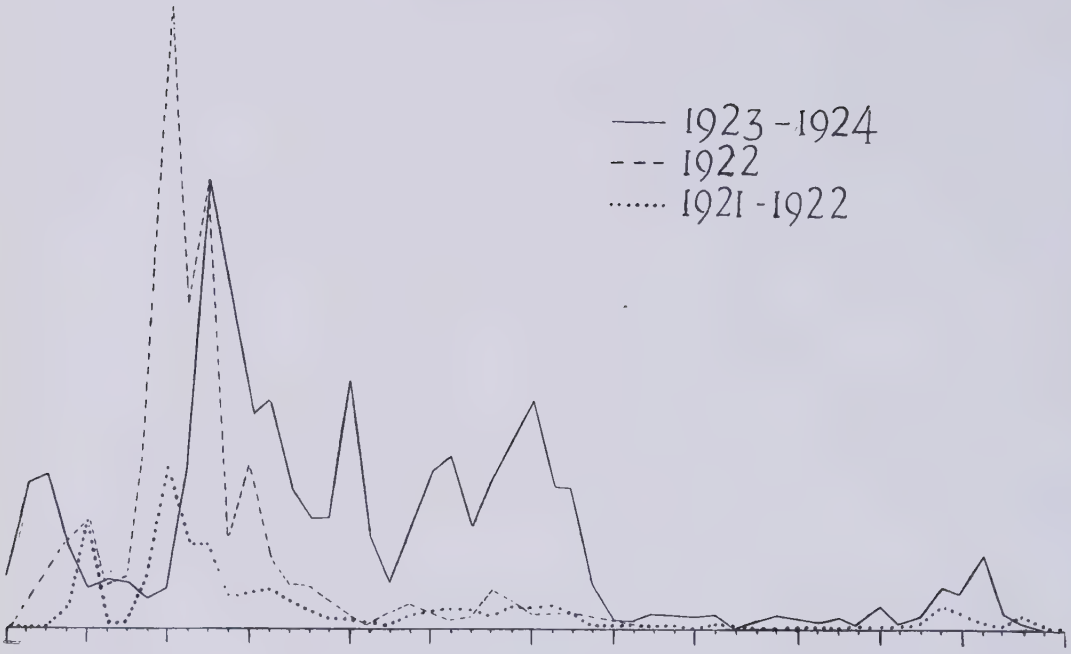
TABLE II.

NUMBER OF WEEVILS COLLECTED IN BANDS EACH MONTH FROM MAY, 1922—DECEMBER, 1922.

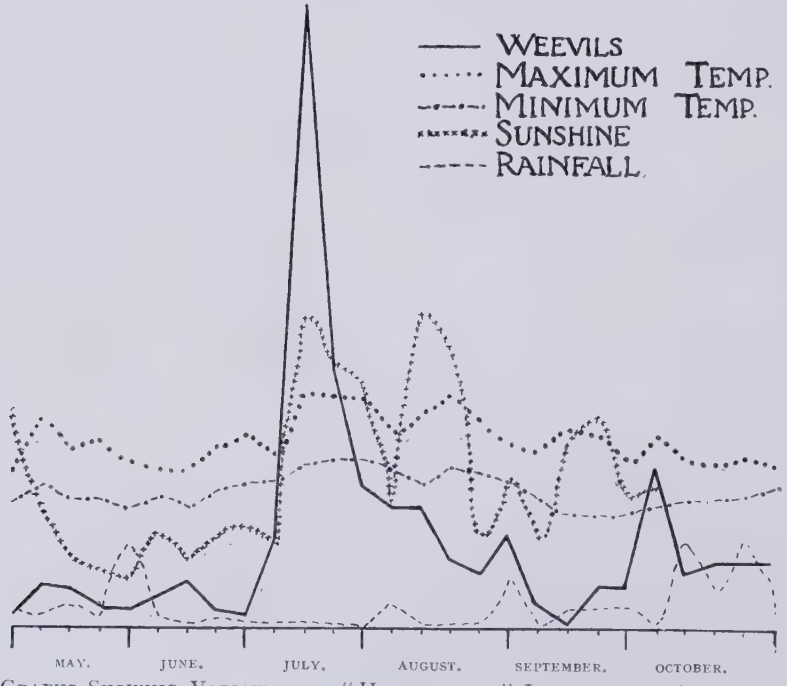
		No. of Weevils in 64 Bands.	*Monthly % of Total Trapped.*
1922	May	136	5.3
1922	June	943	37.0
1922	July	1,090	42.7
1922	August	130	5.0
1922	September	68	2.6
1922	October	110	4.3
1922	November	63	2.4
1922	December, 1st wk.	8	.3

It will be noticed that in both seasons the greatest number of weevils were taken in May, June, July, August, and October. These preliminary experiments were repeated between May, 1923, and April, 1924, but closer observations and fuller records were made. A plot of James Grieve Apple trees was this time selected. The trees used were a year younger than those used the previous season, although they were all on the same pruning plot. As before, all trees were banded with old sacking, at about fifteen inches above ground level. This banding began during the last week in April. Observations upon the bands for the collection of weevil were carried out weekly for a complete year. The object was, as already stated, to find out when the weevils were coming into the bands, and so check the previous year's figures. However, in this experiment the weevils caught weekly were not destroyed, as in the previous

PLATE IXa.



A. Graphs Showing Variation in "Hibernation" Impulse over a Period of Three Years.



B. Graphs Showing Variation in "Hibernation" Impulse and Accompanying Weather Conditions.

case, but were put aside in order to study the development of the ovaries, and afford material for making certain observations on the life history of the weevil. These points will be dealt with later. The following figures summarise the result of this third year's analysis and should be compared with Tables I, and II.

TABLE III.

NUMBERS OF WEEVILS COLLECTED IN BANDS EACH MONTH FROM MAY, 1923—APRIL, 1924.

		No of Weevils in 64 Bands.	*Monthly % of total trapped.*
1923	May	461	10.0
1923	June	170	3.7
1923	July	1,151	25.3
1923	August	838	18.3
1923	September	395	8.6
1923	October	833	18.2
1923	November	360	7.8
1923	December	59	1.3
1924	January	54	1.1
1924	February	33	.7
1924	March	103	2.2
1924	April	107	2.3

The curves (see Plate IXA), for the three years emphasise strikingly the fact that June and July are consistently the months when the greatest number of weevils enter the bands, and that the months after October are, comparatively speaking, ' rest ' months. Considerable movement, this time out of the bands, begins again about the beginning of March.

The evidence seems to show that these movements are definitely dictated by a more or less fixed life cycle, possibly varying slightly with the time of blossoming. It appears that about one month after egg-laying, there is a general impulse to seek rest. This rest seems very general for the period of three to six weeks, after which more moving about is again obvious until October, when there is a marked influx of weevils once more.

In order to see how far these movements coincided with weather conditions, a graph has been plotted for six months showing the temperature, sunshine and rainfall curves in comparison with the curve representing the impulse to " hibernation " of the weevil. It will be noted that weather and temperature conditions bear no apparently close relationship to this movement. Some consideration has also been given to other possible external factors which might influence the movements of the weevil. For instance, it was possible that they might be more attracted to the trees full of blossom rather than to those markedly less so. The pruning plots upon which these observations have been carried out were

very suitable for such an analysis, since the rows of "unpruned" and "regulated" trees generally showed a notable increase in blossom, against both the long and short spurred rows, which were also "leader-tipped." The figures for the year 1923 gave the following indications :—

16 unpruned trees .. .. 1,286 weevil caught.
15 Regulated trees .. .. 1,207 weevil caught.
16 Tipped and Long Spurred Trees 1,082 weevil caught.
17 Tipped and Short Spurred Trees 995 weevil caught.

A distinctly more marked result came from a study of the location of the trees. At one end of the plot is a poplar hedge, the bottom of which might be expected to afford cosy winter quarters, with fallen leaves, rough grass and loose bark. The other end of the plot abutts on a much used roadway, where no such facilities exist. The following are the figures :

31 trees nearest road .. .. 2,036 weevil caught.
32 trees nearest hedge .. .. 2,534 weevil caught.

The question of varietal susceptibility was also considered. In 1922, Worsley banded thirteen of the varieties represented on the pruning plot. In practically all cases thirty-two trees of each variety on each stock were banded, though in occasional instances bands fell off individual trees before the completion of the experiment. The following are the figures, when all the bands were taken off at the same time in December :—

TABLE IV.

Variety.	*Years old.*	*Weevils caught.*
Annie Elizabeth	6 years	134
Bismark		178
Early Victoria on "Par."		214
Rival		236
Gladstone on "Par."		283
James Grieve on "Par."		287
Norfolk Beauty	8 years	228
Gladstone on "Crab"		275
Cox's Orange Pippin		302
James Grieve on "Crab" ..		298
Lord Derby		313
Early Victoria on "Crab" ..		339
Worcester Pearmain		420
Grenadier on "Par."		436
Grenadier on Free Stock	9 years	481
Beauty of Bath		472
Lane's Prince Albert		457

Before banding could be recommended as an economic method of controllng Apple Blossom Weevil, it was essential to discover how far the trapped insects actually represented the generation capable of carrying on the race in the following season, and how far they were merely " spent females " which had once and for all done their work, and hibernated until overtaken by natural death, as has been suggested. In order to settle this point, all weevils that were found in the bands in June and July, the principal months for immigration, were kept in captivity and under observation. In the following Spring, they were put on to young Apple trees in pots. In all cases, these weevils lived, and after copulation, the females deposited their eggs in the flower trusses. These observations were checked for two seasons. Under certain conditions adult female weevils survived to the second blossoming season and actually laid eggs in two consecutive years. In recent work, Speyer[7] found that *Anthonomus pomorum*, L., Curtis, may have two oviposition periods, and these results have been confirmed by further experiments. Under conditions at Malling, it was found that the trapped weevils showed an almost equal proportion of males and females, though it has been generally considered that the former were more numerous. Although the actual number of weevils trapped on sixty-four trees does not appear to be very large, the amount of damage they would have done upon these young trees can be approximately gauged when it is realised that each female is capable of destroying up to sixty blossoms. According to Speyer[7], it is possible for one female to lay as many as 144 eggs, the egg-laying period being extended over two years. As the trees grow larger, if the weevil population does not increase in proportion, the damage tends to become more insignificant. Despite our trapping, the weevil population, as estimated by those caught, has steadily increased each year, and yet the damage done is undoubtedly less serious than it was in 1920 and 1921. The fact that there is some migration from tree to tree and possibly even from one plantation to another would be sufficient to account for this actual increase, since our experiments have in the main been confined to the regular banding of only sixty-three trees in a three and a half-acre plantation. If the trapping had been as systematic as it appears promising, there is reason to suppose that very large catches of weevil would have been recorded.

That banding would be worth while under conditions such as ours was so evident that certain details were elaborated from the practical point of view, in order to guide the grower as to the seasons for application and removal of his bands, and their actual manipulation, etc. With regard to the best time for application, our graphs have shown that June and July are constantly the most vital months, and that therefore the bands should be applied if possible by the end of May.

The question then arose as to whether the bands should be removed immediately after this influx, say in August, in order to destroy this biggest number,

or whether it would be safe to leave them on until well into the winter, secure in the knowledge that the weevil that sought shelter in June and July would not emigrate again in quantity. Since figures constantly showed that weevils in fair quantity continued to come into the band until the end of November, it would naturally be desirable to leave these bands on if no loss of previous captures were entailed thereby. To determine what was acually happening, a series of trees were banded, and instead of all the bands being removed weekly for examination, as in the former series, only a certain number were removed at fortnightly intervals. For instance, the first batch of eight bands were examined after they had been on the trees two weeks only, the second batch after they had remained four weeks, and so on, until the last batch was removed after twenty six weeks duration on the trees without disturbance. The following table (No. V) shows the steady increase right up to the time when the weevil are observed to emerge, towards the end of February.

TABLE NO. V.

ILLUSTRATING THE STEADY MONTHLY INCREASE OF IMMIGRATING WEEVIL. UP TO FEBRUARY.

All bands put on trees 10th Sept., 1923.	Number of Weevil in bands.
Bands removed after 2 weeks	24
,, ,, 4 ,,	59
,, ,, 6 ,,	120
,, ,, 8 ,,	158
,, ,, 10 ,,	158
,, ,, 12 ,,	172
,, ,, 14 ,,	181
,, ,, 16 ,,	207
,, ,, 18 ,,	208
,, ,, 20 ,,	229
,, ,, 22 ,,	248
,, ,, 24 ,,	205
,, ,, 26 ,,	189

Even the periods of severe weather during the Winter of 1923-24 did not disturb the weevils which remained in the bands during frost and snow. Once, then, the weevils get into hibernation they do not appear to move about to any considerable extent, though some, as our figures indicate, either must change their quarters, or seek hibernation very late in the season. On one plot of trees where the bands were removed weekly, in order that the number of weevils might be recorded, but not disturbed, the number of weevils actually remained unaltered during the whole twenty-six weeks. Is it evident, therefore, that it is quite safe

to leave the bands on the trees until late in the year, and the best time for their removal is during the months of December or January.

In order to see whether it would be possible to make the sacking traps more attractive by different manipulation such as folding, etc., careful records were taken over two seasons of the position of the weevils in the sacking traps. Whilst the first season gave the most decided results in favour of the fold, the second season reversed the position.

	1922-3	1923-4
% of weevil caught in fold	68	27
% of weevil caught between sacking and stem ..	32	53
% of weevil remaining on stem	—	20

The variation may be a seasonal one, but in any case the double thickness of banding must afford more protection in cold and wet seasons, and the more weevils that can be removed in the band, the fewer will there be left on the bark or liable to be shaken off on the ground. It is interesting to note that with normal rough handling of the bands, eighty per cent. of the weevils at least would have been removed undisturbed.

With regard to the position of the weevils above and below the " tie," certain data are available. They were distributed in almost exactly equal numbers (forty-seven per cent. above tie, fifty-three per cent. below tie) in the sacking above and below the string tie. The weevils therefore appear to enter the bands both from above and below ; this should dispose of the growers' theory that it is necessary to tie the bands as near the top as possible, since all the weevil crawl up from the ground into the sacking from below.

Methods of Manipulating the Bands.

Discarded bags which had contained meal and artificials and other waste sacking was collected and cut into long strips. The width of each strip was about six inches, and each strip was cut in length so that it would be at least twice that of the circumference of the tree, in order that the band could be of double thickness by folding across the middle. Many other methods of folding bands have been tried, for example, bands folded lengthwise (or doubled over) did not attract many weevils, neither did single bands placed round the tree without any fold at all. The double thickness of sacking which allowed free entrance both above and below the tie, gave the best results over a period of three years.

Position of Bands on Trees.

The best position of the band on the tree was also investigated, and it was found that this detail might make the whole difference between success and failure. In order to ascertain if the position did materially affect the number of

weevils going into the band for the winter, a series of trees were banded at different heights. One set of trees which were originally headed back at two feet had bands placed so that the base was about twelve inches above ground level. The other series had the bands at the base of the trunk so that they just touched the ground. The bands were put on in September, 1921, and left till the end of December. Whilst 106 weevils were collected from the bands placed at twelve inches from the ground, only five were taken from bands on the ground level. The work was repeated the following year, and a similar result was obtained on a larger plot of trees. Where the bands were placed as near the fork of the branches as possible, 625 weevils were captured as against 269 which were taken from those close to the ground. It seems probable that the difference in effectiveness is due to the fact that whilst the bands at ground level remain sodden all Winter, those in a higher position remain comparatively dry. It should be pointed out that trees grown on a very short leg, in many cases only a six inch leg, would be much more difficult to band successfully.

It might be mentioned here that apparently the kind of sacking used for catching the weevils is not of importance, for example, weevils seemed to be attracted to the old uncleaned guano bags, to the same extent as to old hop-pocketing, or even new sacking.

At the request of Mr. Miles, of Long Ashton, the use of paper bands, as compared with sacking, was tested in 1922. These bands were first applied on May 5th, and were not ultimately removed until December 10th, though they were examined as frequently as the sacking bands with which they were being compared under our conditions. At the end of the period a total of only eighteen weevil had been recorded in the paper bands, as compared with a total of one hundred and thirty-six in a similar number of sacking bands. Under our particular conditions these results did not appear to call for further trial.

On our small scale, we have usually burnt our sacking bands in order to destroy the weevil, but where such a measure is to be used on a considerable scale, economy in sacking might be necessary. If the sacking is good enough to save for a second season, it can, immediately after removal from the tree, be thrown into a tub of water with a few stones to sink it and prevent it floating. A film of paraffin can then be poured on the surface of the water, and this will ensure the destruction of the weevils. In due course (after it has been ascertained that all the weevils are dead), the tub can be carefully emptied, the strips of sacking dried, and used again the following May.

Incidentally these sacking bands trap various other insects both in Summer and Winter. Earwigs are very common during the Summer months, and when the weather is very warm great quantities of green-fly (*Anuraphis roseus*, Baker) have been found to shelter in the bands. The larvæ of Syrphid flies, which devour the green-fly, follow. In the Spring, the Clay Coloured Weevil

(*Otiorrhynchus picipes*, F.) is commonly found in the bands in considerable numbers, and this suggests a possible method of controlling this pest when it is ravaging newly-grafted stocks. Close examination also showed that another species of weevil, possibly often mistaken for the Apple Blossom Weevil (*Anthonomus pomorum*, L., Curtis) are not uncommonly to be found in the bands. Some of the small specimens found may prove to be a closely allied species, well known on the Continent as *Anthonomus humeralis*, Panz = *incurvus*, Panz. This species was first recorded in this country in 1869 by Stephens[9], but seems to have been overlooked since then. Other closely allied species of *Anthonomi* are to be found in the bands ; *Anthonomus cinctus* and *Anthonomus rubi*, Herbst, are of frequent occurrence. Various species of larvæ are also common in the bands, and some actually pupate in the fold of the sacking.

Finally, a word may be said as to the amount of parasitism that takes place among the weevils during the larval stage. In order to shed some light upon this point 5,000 " capped " blossoms were collected and allowed to develop normally whilst they were kept under observation. Over ninety per cent. of these blossoms produced weevils. The rest failed to mature. Only five parasites were observed, belonging to an hymenopterous parasite of the family Ichneumonidæ (genus, *Pimpla*). So that under our conditions at least the " parasite " did not appear to be a very promising corrective.

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THE CONTROL OF BIG BUD MITE IN THE FIELD.

By R. G. HATTON, J. AMOS, & H. M. TYDEMAN.

The experimental work on the control of Big Bud Mite on Black Currants in the field, already described in the last Annual Report (1923), has been continued for another year. This study was commenced during the Winter of 1921-1922, on an acre plot of Baldwin Blacks, interplanted between Apple trees and laid out in 1920. The bushes were divided into eight equal plots, of ninety-seven bushes, each comprising a single row of bushes across the plantation at five feet apart, and a short intermediate row at fifteen feet apart standing between the Apple trees. The plots ran north and south, Plot 1 lying to the western extremity and Plot 8 at the eastern extremity. Our observations on the distribution of the Big Buds among the plots show the greater severity with which the series of plots on the eastern half of the plantation have become infected when compared with the plots receiving corresponding treatments on the western half. The most obvious of possible agencies influencing this migration in an easterly direction appears to be the wind. During those months in which migration chiefly occurs, namely April, May and June, our records show that westerly winds predominated over easterly winds by fourteen days in 1921, by thirty days in 1922, by seventeen days in 1923, and by nine days in 1924. While westerly winds predominated consistently throughout the Mays of four years ; two exceptions occurred in April (those of 1923 and 1924), and two in June (those of 1921 and 1924).

During the early Spring of 1922 and of the three subsequent years the plots were treated as follows :—

Plots 1 and 8 all Big Buds hand picked during early Spring.

Plots 2 and 7 sprayed with Lime Sulphur at Winter strength during the Spring.

Plots 3 and 6 odd numbered bushes cut down almost to ground level during one Spring ; even numbered bushes similarly treated next season.

The results of these treatments are compared with those from untreated (control) plots (Plots 4 and 5).

Each treatment is duplicated at opposite extremities of the plantation in order to eliminate as far as possible differences attributable to soil variation or other factors. The planting of the control plots at the centre of the plantation had the obvious advantage of limiting the risk of infection from these untreated bushes to other valuable experimental plantations in the vicinity.

Moreover these control bushes formed an active central source of infection to the treated plots. In this connection, it is worth noting that, although the lime-sulphured plots were nearer to the untreated control plots than the hand-picked plots on the outsides, lime-sulphur spraying gave a larger measure of control than hand-picking. In measuring the full value of lime-sulphur spraying under our conditions this proximity to serious infection should be remembered. Elsewhere, where such sources of infection are absent, we find the measure of control even greater.

Details of Treatments.

Our hand-picking treatment consisted of removing all obviously enlarged buds during early Spring. It is necessary to stress the fact that this operation, to be most effective, should be performed at as late a date before bud-break as possible, since we have evidence here that the number of enlarged buds increases slightly between, say, November and March. While it is not suggested that the mite could have infected fresh buds during this period, these facts seem to indicate that mites in buds, not apparently enlarged in the early winter, may be capable of causing such enlargement by the following spring.

The lime sulphur spray used was that recommended by Mr. A. H. Lees* (concentration 1 to 12, specific gravity 1.025). While however, Mr. Lees recommended its application when " the leaves are the size of a sixpence ", under our conditions the spray appears more effective if applied at a slightly later date. Thus, in 1922, 1923 and 1924 respectively, the leaves of our Baldwins were on the average the " size of a sixpence," on March 10th, March 14th and April 8th, yet the average date on which we applied the spray in those years was ten days to a fortnight later. We aimed at applying the spray after the flower racemes had appeared, but before the flowers had opened. Although we have not carried out a special series of experiments designed to test the optimum time for this spring spraying, the results of spraying upon our Variety Trial Plots seem to emphasise the value of leaving the operation until the last moment.

Let us compare the measure of our success upon the two whitish ragged budded varieties, Baldwin and Goliath, the former very early in leaf, the latter late. Both these varieties are reputed to be highly susceptible to Big Bud, and, until 1924, they were both sprayed each year on the same day with Lime Sulphur, the Baldwin's being far in advance of the Goliaths.

The control has been much greater on the former, the total number of big buds recorded from the seventy-three bushes of Baldwin being fifteen on eight bushes as against eighty two on fifty two bushes of Goliath. Such evidence is of course only very indirect, since the factors of both variety and location render strict comparison impossible.

* Annual Report, Agricultural and Horticultural Research Station, Long Ashton, 1919.

With regard to the economic aspect of the use of lime sulphur spray, it has been stated that, according to our own figures, this method of mite control is unjustifiably expensive when compared with hand-picking. This idea has doubtless arisen from the fact that the cost of spraying was stated, in error, in one instance, as approximately 4d. per bush. The actual cost of lime sulphur spraying at this Station in the Spring of 1925, using a motor spraying plant, and taking every expense into consideration, worked out at a little less than a penny per bush, or, at 1210 bushes per acre, £4 10s. 9d. Bearing in mind the undoubtedly superior performance of the lime-sulphur spray under our conditions we consider the cost of this operation justified.

The method of cutting the bushes down in alternate years with the object of obtaining fresh supplies of young uninfected wood has several disadvantages. In the first place, only half the bushes are cropping in any one year. In the second place, since the treatment is only applied to half the bushes each year, the control over the spread of mite is only exercised on that half in any one year. The cropping bushes upon the cut down plots in 1923 gave an aggregate crop slightly in excess of the lime sulphured plots, as may be seen from Table 2, though the cropping bushes on these same plots yielded on the average 10 ozs. less fruit per bush than the latter in 1924. So that, in addition to the loss of half the crop in each year as the result of the treatment, there appears to be an actual diminution of crop ultimately, on the bushes so drastically pruned. Again, whilst the treatment must have removed a large percentage of sources of potential infection, buds containing Mite must have remained on the stumps left after cutting down the bushes, since it has been no part of the treatment to hand-pick or lime-sulphur these stumps. It was noticeable on these plots that the majority of the Big Buds which occurred on new growths, in the season following that in which the bushes were cut down, were clustered around the lower half of the shoots.

Measure of Control Attained.

A.—On Healthy Bushes.

The results of actual counts of Big Buds taken during the Winters of 1922, 1923 and 1924, are shown in Table 1. In 1921, before the treatments were applied, each plot had a few Big Buds. The figures in Table 1 are based on the "unreverted" bushes only, even those showing less than the normal number of innervated points in the leaf serration being excluded.* Considerable casualties from reversion occurred in each year, as will be shown later,

* "Reversion of Black Currants, A method of Identification," by A. H. Lees. Journal of Ministry of Agriculture, March, 1921. Referring to such a case, Mr. Lees says, "It has, therefore, a distinct touch of Reversion in its make-up, and any bush having such leaves is suspect."

and our first object was to ascertain how far we could establish control over Big Bud on healthy bushes.

TABLE I.

Showing % of Bushes infected with Big Bud and the severity of attack.

	1921		1922		1923		1924	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
Plot 1 Hand-picked ..	2	7	18	27	67	144	96	924
,, 8 ,, ,, ..	5	15	23	97	81	272	100	1758
**Both .. .. ..

the time of spraying is an important factor determining the precise amount of control obtained. Hence, it is conceivable that spraying may meet with a different measure of success under different climatic conditions. On the other hand it appears possible that the effects of such a spray are " cumulative " and that the measure of control (over mite infection) obtained increases in each succeeding year.

The effect of the lime-sulphur spray on the mites has been followed out in the Laboratory by Mr. A. M. Massee, and it has been found that the mites are killed by the spray as soon as they commence to migrate from the big buds.

If the big buds are examined under the microscope, a week or more after the application of the spray, dense masses of dead mites will be observed on the surface of the old drying up diseased buds.

Figure A illustrates a typical big bud, sprayed with lime-sulphur, on which masses of dead mites are seen.

Figure B represents one of the big buds taken from a control bush. In this instance mites are seen migrating from the bud in the normal way. These mites would normally re-infect some of the new buds the following Summer.

Hand-picking, which gave promising indications in the early years of the trials, was much less effective in 1924. The most obvious explanation appears to be that the removal of the enlarged buds has not eliminated mite from the bushes entirely, but that mite has remained in unenlarged buds ; on several occasions Mr. A. M. Massee has found this to be the case. It should be recalled that the plots in question are furthest removed from the worst sources of reinfection.

Of the method of cutting down the bushes in alternate years, the best that can be said is that under our conditions a very slight control is obtained. A detailed study of the individual bush records shows that the bushes cut down in one season, after becoming temporarily less severely attacked in the year in which they are forming new shoots, become almost as badly affected as the untreated control plots by the second year.

Effect of Treatments on Cropping.

Throughout the course of the experiments, crop weights of individual bushes were kept. Table II. shows the average crop per " unreverted " bush in each year.

Table II. shows that the cropping of the various plots has been somewhat uneven. The consistently higher cropping of the four most easterly plots again seems to suggest some local advantages. The figures indicate however that the crop has not been seriously diminished by the use of lime-sulphur. The method of cutting down the bushes in alternate years has, on the other hand, resulted in a serious loss of crop in 1924. This is especially interesting

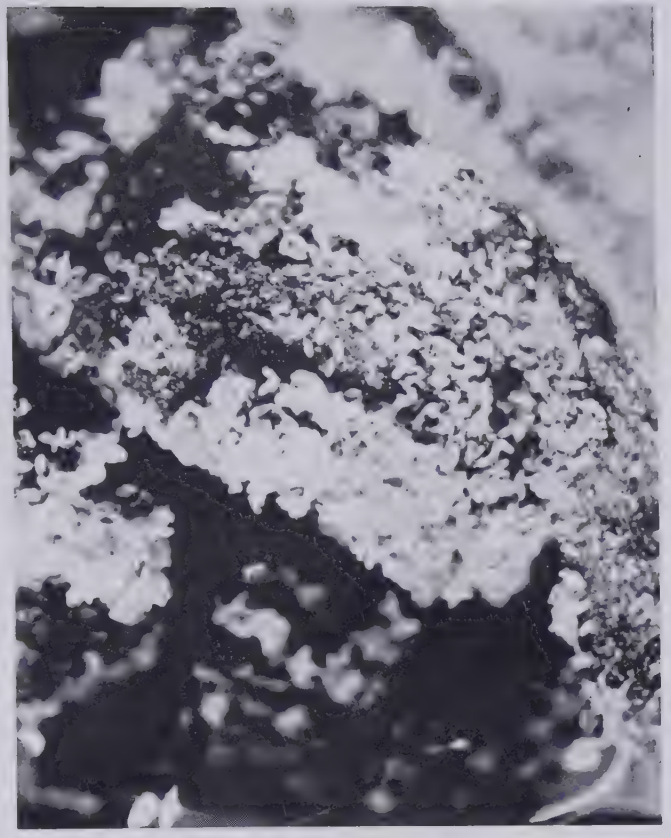


FIG. A.

BLACK CURRANT GALL MITES (*Eriophyes ribis* Westw., Nal.) KILLED BY LIME-SULPHUR SPRAY.

FIG. B.

BLACK CURRANT GALL MITES (*Eriophyes ribis* Westw. Nal.) MIGRATING FROM UNSPRAYED "BIG BUD."

when it is remembered that the bushes on the other plots have never been pruned. The "probable errors," worked on the 1924 figures, indicate that the differences between the cropping of the plots are not as significant as they may appear and are probably the result of soil variation or other causes. The only really significant differences are those indicating diminution of crop following cutting down in the previous year. Though the very hard cutting certainly appears to increase fruit size somewhat, it produces growths with very long internodes between the possible fruiting buds.

TABLE II.

Average Crop per Bush in Ounces.

		1922 Ozs.	1923 Ozs.	1924 Ozs.	Average of 3 years. Ozs.
Plot 1	Hand Picked	5.7	41	95	47
8	,, ,,	7.3	59	112	59
Both	,, ,,	6.5	50	103.5	53
Plot 2	Lime-Sulphur	6.2	39	95	47
7	,, ,,	6.6	43	101	50
Both	,, ,,	6.4	41	98	48.5
Plot 3	Cut Down	5.0	43	82	43
6	,, ,,	4.8	44	81	43
Both	,, ,,	4.9	43.5	81.5	43*
Plot 4	Untreated Control	5.9	41	97	48
5	,, ,,	6.1	46	110	54
Both	,, ,,	6.0	43.5	103.5	51

B.—On Reverted Bushes.

Since it is clear that some of the treatments give a good measure of control on healthy bushes, it is worth while to enquire what effect they have on the Big Bud on the "reverted" bushes, more especially as it is well known that Big Bud is apt to spread very rapidly on such bushes. In 1921 and 1922 the reversion was so sporadic that the figures are incapable of interpretation. In 1923 and 1924, however, the Big Bud on definitely "reverted" bushes was appreciably controlled by lime-sulphur; whilst the untreated "reverts" showed 11,575 Big Buds per 100 bushes in 1923 and 8,968 in 1924, the lime-sulphur sprayed bushes showed only 5,225 and 3,150 Big Buds per 100 bushes respectively.

* It must be remembered, in addition, that under this treatment only half the bushes are cropping in any one year.

Effects of Treatments on Spread of "Reversion."

The bushes used in these experiments were obtained from an ordinary commercial source and had been propagated from plantations which we knew contained a considerable percentage of wholly and partially "reverted" bushes. It is therefore more than probable that a number of the young bushes when planted were either already "reverted" or at least infected with "reversion." Hence, it is dangerous to seek any effect of our treatments on the spread of "reversion" until this incipient "reversion" had worked itself out. We have, from other material, evidence that this process often takes at least two seasons. In this connection the actual manifestations of the trouble are of considerable interest. In the first two years (as noted above) "reversion" occurred sporadically in the plots and in nearly every case the affected bushes "reverted" completely in a single season and apparently without any previous attack of Big Bud. In 1923, and still more in 1924, the manifestations became very different; in the great majority of cases the newly "reverted" bushes *had* previously shown Big Bud and the "reversion" itself generally appeared gradually, i.e., on only part of the bush at first. It is, then, perhaps fair to assume that, at any rate by 1924, fresh cases of "reversion" indicated new infections and not the legacy of careless propagation. When we find that just at this period the great majority of the new "reverts" appeared in the untreated and cut down plots, we are surely justified in suggesting that the lime-sulphur spray and the hand picking may have in some way checked the spread of "reversion". Thus, whilst in 1924 the untreated plots showed 18 per cent. of definite new "reverts", the lime-sulphur sprayed plots showed only 4 per cent. and the hand picked plots 5 per cent. The worst of all were the cut down plots, with 23 per cent. This line of observation will become more interesting after yet another season has elapsed.

Summary.

In the light of these field experiments, then, in conditions such as ours we can confidently recommend the spraying of Black Currant bushes with winter strength lime-sulphur wash (1.025 sp.g.) just as the bloom trusses are appearing but before they open. Slight scorching of the very young leaves will almost certainly result but the bushes though temporarily looking yellowish in foliage seem to suffer no ultimate damage. On several occasions the small undeveloped abortive flowers which appear in certain seasons have been mistaken by growers for lime-sulphur damage, but we find these coming just as frequently in the other rows. Microscopical examination of the buds from these lime-sulphured bushes during the migration season has revealed masses of dead mite upon the old Big Buds. Lime-sulphur spraying has become a matter of routine here, even in the cutting beds.

SPECIMENS AND PESTS RECEIVED DURING THE YEAR.

By A. M. MASSEE.

From amongst the numerous enquiries received at East Malling during the year with regard to damage by insects, two very prevalent pests last season appear worth special comment.

(1) *Black Currant Leaves damaged by Clay Coloured Weevil.*

Growers from several parts of the country have been enquiring into the cause of the drooping and falling off of Black Currant leaves during the Spring and early Summer. The attack is more noticeable on young or newly planted bushes, which are sometimes completely defoliated.

The general opinion appeared to be that high winds were responsible for the damage.

Investigations showed that this was not the case, but in reality the damage had been caused by the Clay Coloured Weevil (*Otiorhynchus picipes*, Curt.).

This Weevil rests in the soil around the bushes during the day-time. At night it goes on to the bush, and feeds on the petioles and leaves and young shoots. In some cases the petiole is eaten right through, causing the leaf to fall off. In other instances is partially eaten away, causing the leaf to sag. Eventually these leaves dry up.

(2) *Beetle Mites* (*Oribatidæ*).

Many enquiries have reached us this year, regarding these Mites, which have been very plentiful.

The Beetle Mites (*Euzetes lapidarius*, Mic.) vary in colour from brick red to deep red, others again are quite black.

They are commonly called Beetle Mites because of the beetle-like hardness of their integuments.

In common with the whole group, the Beetle Mites have no eyes, but at the same time they are very sensitive to light, and may be observed to move off very rapidly to a dark retreat, when exposed to a powerful light. They have four pairs of legs, the last joints of which terminate in strong claws.

They are very small, the average being about a twentieth of an inch in length. Normally, they hibernate as adults in moss and lichen. Eggs are laid in very large masses on fruit trees, they are small and round, and of a brick red shiny appearance. Sometimes the eggs are so numerous on fruit trees, that they are of a rusty red appearance.

It has often been stated that they are quite harmless to fruit trees in this country, and are in fact said to be beneficial, as they feed on fungus spores and lichens. Recent work also supports this view.

Very little time has been given to this question, but casual observations show that in some instances they may be very troublesome to growers.

Last Summer several Cherry growers reported that their fruit was infested by a small Mite, which they said did not appear until the fruit was nearly ready for gathering.

The Mites collected in large clusters around the stalks of the cherries and in some cases on the fruits themselves. In at least two instances the Mites were so numerous that the crops were ruined. This might be an exception to the general rule, but in view of the fact of what has taken place, further observations on these Mites is very necessary.

Part V

Hop Experiments

Part V

HOP EXPERIMENTS.

THE TESTING OF NEW VARIETIES OF HOPS.

By R. G. HATTON and J. AMOS.

In collaboration with Prof. E. S. Salmon, of the S.E.A.College, Wye, the work of testing the best of his new varieties of Hops against named commercial sorts has been continued.

Fortunately, owing to the late issue of this report it is possible to review both Prof. Salmon's reports for 1923 and 1924, being the Seventh and Eighth respectively.

It is satisfactory to note that the records of weight of crop and quality fully confirm the indications hitherto obtained that many of the new varieties possess both cropping power and resin content far above the great majority of commercial varieties grown, and suitable to grow, in this country.

In the following Tables will be found the performance from year to year of some of Prof. Salmon's most outstanding Seedlings, because out of the hundred or so varieties picked, weighed and dried separately at Malling, it is now possible, in many cases, to indicate those most likely to be of interest to Growers. Indeed, our gardens are now almost bewildering in their multitude of varieties, and growers may be glad to concentrate their attention upon a few outstanding types.

The records speak for themselves and only require supplementing by references to Prof. Salmon's detailed reports. In the majority of cases it is as yet, of course, unsafe to suggest that any average crop figures are reliable. These crop weights are based on a uniform healthy plant of 889 hills to the acre, but the averages must be taken as a mere indication of the sort of performance that may be expected under conditions such as ours. Our hops are all trained on Butcher Wire-work 13½ feet high, and the scheme of manuring adopted since 1921 is fully detailed in the Eighth Report on the Trial of New Varieties (1924).

The chief features of 1923 may be summarised as follows :—

" Of sixty new varieties tested, fifteen cropped at the rate of over a ton to the acre, while no less than fourteen, on analysis, proved to contain more than 15 per cent. total resins, an amount well in excess of any commercial variety grown in this country.

" A sample of American (Oregon Cluster) Hops of 1923 growth were obtained,—the sample being selected as the richest on the Market. This sample

Table showing Cropping from year to year of New Varieties in cwts. per acre.

EARLY.

Name or Ref. No.	Parentage.	1919.	1920.	1921.	1922.	1923.	1924.	Average.	Special Qualities.
L21 ..	Tolhurst × Selected English male.	15½	25¾	16¼	29¾	16½	32¼	22⅔	Much higher in total and soft resins than Tolhurst.
458 ..	Seedling of parentage (Saaz and English male) × English male.			12½	25¼	18¼	32¼	22 1/16	Large hop.
X35 ..	D9 of unknown origin × Selected English male.				14½	12¾	30¾	19⅓	Very high in total and soft resins.
M20 ..	Same as X35				17½	16¼	28¼	20⅔	High in total and soft resins.
OD8 (" Jenny ")	Danish Asperup × Selected English male (G17).				23¾	14¾	26¾	21¾	Good appearance.
P13 ..	Seedling from German Saaz.	9¾	20½	16¾	15	13¼	20¾	16⅔	Very high in soft resins. Good appearance and aroma, immune from mosaic.
X53 ..	Seedling of parentage (Saaz × English male) × English male.				15¼	12¾	26	18	High in total and soft resins. Big cones.
Bramling ..					20¾	13½	26¾	20⅓	

Table showing Cropping from year to year of New Varieties in cwts. per acre.

MIDSEASON.

Name or Ref. No.	Parentage.	1920.	1921.	1922.	1923.	1924.	Average.	Special Qualities.
L40 ..	Seedling of Parentage (Saaz × English male) × English male.	28½	18¼	34	24¼	36	28 1/5	High in soft resins. Immune from "Mosaic."
OF24 ..	Late German Variety (260-1) × English male.			13	16¾	30¾	20 1/12	Very high in total and soft resins.
OQ17 ..	Seedling of M45.					23¾		Very high in total and soft resins.
K27 ..	C15 of unknown origin × selected English male.			18	16¾	28	20 1/12	Good appearance.
P39 ..	Seedling of hop ref. number F1 of unknown origin.			15	14½	27½	19	High in total and soft resins. Good appearance.
P43 ..	Same as P39	13¾	11½	22	12¾	24¾	16 19/20*	High in soft resins. Good appearance.
Tolhurst ..				20	15¼	34½	23¼	
Mathon ..				26	17¼	37¼	26⅝	
Tutshams ..				23½	15½	28¾	22 7/12	
Fuggles ..				21¼	12¼	26¼	19 1/12	

* The cropping of this variety has undoubtedly suffered as a result of its position in the Hop Garden in an "outside row."

Table showing Cropping from year to year of New Varieties in cwts. per acre.

LATE.

Name or Ref. No.	Parentage.	1918.	1919.	1920.	1921.	1922.	1923.	1924.	Average.	Special Qualities.
OH8 ..	Canterbury Whitebine × Male Hop.					17	18½	36	23⅝	Good appearance.
Y86 ..	Fuggles × English male.			23¾	21¼	30	22½	32½	26	"Hangs" exceptionally well, resins fair, good appearance.
M45 ..	Oregon Cluster × English male.	18¼	15½	22¾	14	20¾	20¼	33½	21⅞	Rich in soft resins, good appearance and aroma, immune to "Mosaic," but believed to be a "carrier" of this disease.
F25 ..	M52 (Oregon Cluster × English male) × English male.							23¾		Very rich in resins.
OF27 ..	German Hersbruck × English male.					28	21	32	27	Very rich in resins. Good appearance.
OP21 ..	K52 (Oregon Cluster × English male) × English male.					20¾	21	31¾	24½	Very rich in resins. Good appearance.
OV7 ..	Late Bavarian × Selected English male.					28¼	25	30¾	28	Very rich in soft resins.
OW60 ..	German Elsass × English male.					14½	15¼	26¼	18⅜	Rich in soft resins.
310 ..	Golden Hop × English male.							27¼		Immune to mould.
OF37 ..	Late German Variety (260-1) × English male.					16¾	20½	27½	21 7/12	Rich in resins.
OE40 ..	Same as OF37					15¼	15¼	26½	19	Rich in resins.
OG1 ..	Same as OF37						15¼	34½		Rich in resins.
OF38 ..	Same as OF37							21¼		Very rich in soft and hard resins.
Colgate ..						28½	16½	33¾	26¼	
Canterbury Golding ..								25¾		

contained 19.0 per cent. total resins, of which 11.84 per cent. were soft resins. It is of great interest to find that we grew in 1923 at the East Malling Research Station two new varieties (OF27 and OE40), which, with 19.14 per cent., and 19.09 per cent. respectively of total resins, exceeded the *total* resins-contents of this richest Oregon Hop. The highest soft resins percentage of these new varieties, however, did not exceed 10.55 per cent. as against 11.84 in the American grown Oregon Cluster. Yet, in another new variety, OV7, the soft resin percentage was 12.72—thus beating the American Hop by nearly one per cent. We have yet to achieve the feat (if possible) of growing the variety which combines in itself the production of a percentage of both total and soft resins higher than that of the best American hops. The results obtained in the season of 1923-24 have advanced us nearer to realising the ideal than before."

The results of 1924 are hardly less encouraging. It was, of course, a year of high yields and exceptional development. Even then three of our late varieties failed to develop sufficiently to be worth picking. These were the Californian Cluster, the Oregon English Cluster and a Seedling (N15) therefrom. To quote from Prof. Salmon's Eighth Report.

" Of the one hundred and eleven varieties tested, no less than twenty-nine cropped at the rate of over 30 cwt. to the acre. Of the Early Varieties, the three heaviest cropping were the New Varieties L53, with 34¾ cwt., and L21 and 458 with 32¼ cwt. ; the highest Commercial Variety, the Bramling, was tenth on the list, with 26¾ cwt.

" Of the Mid-season Hops, the Mathon was top, with 37¼ cwt., followed by the new variety L40 with 36 cwt.

" Of the Late Hops, the New Varieties OH8 and OG1 cropped at the rate of 36 cwt., and 34½ cwt., respectively, followed by the Colgate, with 33¾ cwt."

In cropping, then, many of the New Seedlings proved superior to Commercial Varieties.

" In all the Classes (Early, Mid-season and Late) " to quote Prof. Salmon again, " Certain New Seedling Varieties were preferred by the judges to any of the Commerical Varieties."

With regard to actual resin content " except in the class of Early Hops, many of the New Seedling Varieties produced a higher percentage of both soft and total resins than the Commercial varieties tested." In the Early Class the Meopham, Bramling (one sample), and Amos's Early Bird exceeded any of the Seedlings in total resin, though several of our Seedlings were considerably higher in Soft resins.

In the Late Class, a " new Variety, OF38, produced 20.53 per cent. total resins and 12.22 per cent. soft resins " beating by nearly one per cent. in both cases the richest American Hop tested and by over 3.5 per cent. the richest

English Commercial Variety. On having attained this achievement under our climatic conditions Prof. Salmon is to be heartily congratulated.

Diseases of Hops in Relation to Variety Trials.

A.—The Downy Mildew.

There must also be chronicled one unfortunate set back to this work involving the trial and ultimate introduction of new varieties, which everyone hopes will be only of a very temporary nature.

In 1924, Prof. Salmon had to report an outbreak in the East Malling Experimental Gardens of the Downy Mildew, a disease which was first recorded as a disease of Hops in this country at Wye in October, 1920.

In view of the probability of this proving to be a new and serious disease in this country, Prof. Salmon took every precaution to prevent the spread of the trouble through sets previously sent out from this Station. This involved the destruction of all our sets at East Malling, as well as those in some commercial gardens. Growers must be very heartily thanked for their co-operation in this matter.

More recent investigations show that an identical disease was prevalent upon the hop during the past season in many gardens and districts remote from both Wye and East Malling. There seems no reason, therefore, why cuts or sets should not again be distributed to Commercial Growers, now that the identity of this wide-spread Downy Mildew with that which made itself apparent first at Wye and then at Malling is established by the pathologists.

Hop Growers have been unanimous in their expressions of sympathy at this untoward incident and in their good wishes for the future prosperity of this work.

B.—The Incidence of " Mosaic " Disease in the Hop Garden.

In 1923 the incidence of " Mosaic disease " in our gardens was considerably less than in 1922, the percentage of hills affected in the Commercial Varieties being three, and in the New Varieties, 0.3. It was therefore, disappointing to find in 1924 the recurrence of a somewhat severe attack. No less than 13 per cent. of the hills of Commercial Varieties (especially Cobbs, Bramlings and Early Birds) were affected, and 1.9 per cent. of the New Seedlings.

Many of the New Varieties and Fuggles still show apparently complete resistance.

Mr. F. Cheal, as mentioned elsewhere, has continued, for a second year, his survey of the spread of the disease in our Tutsham Garden in Egham Field.

This garden is three acres in extent and is laid out in Manurial Trials.

He has kindly supplied the following summary of his observations for this report.

Six examinations have been made of the plants, and records kept of their individual appearance. The position of the diseased hills have been plotted on a detailed plan, and can thus be compared with those of 1923 (and 1922 thanks to figures supplied by Mr. J. Amos) and the spread of the disease traced.

A type of mottling (among several types noticed and recorded in 1923) which occurred on the laterals of otherwise apparently healthy hills just before the picking in 1923, has been closely followed up. Sixty-seven per cent. of those plants which were affected with this mottling in 1923, exhibited definite signs of Mosaic Disease in 1924.

There is, at present, no evidence of any correlation between the amount of disease, and any particular form of manuring.

It is hoped to continue the surveys in 1925.

(For other diseases of Hops see Pathological Section.)

SCHEME OF MANURIAL TRIALS WITH HOPS.

By J. AMOS.

Since the different manurial treatments had been carried out, in the case of the organic Nitrogenous and Phosphatic Fertilisers, for a period of three years, and in the case of the Potash manures for one and two years, we confidently hoped that it would be possible to draw some deductions after the 1924 crop had been reviewed.

The crop weight figures for that year alone, did indeed arouse the hope that the differences due to the treatments were beginning to show. However, it was decided to postpone the publication of these figures until the crops for 1025 had been picked and weighed. This was fortunate, since the 1925 results, in several instances, reverse the 1924 indications.

After a careful survey of our methods of conducting these trials, there appears to be no obvious factor clouding the results. It can, therefore, only be concluded, that up to the present our Tutsham Hops have not felt the effects of the different manurial treatments sufficiently to re-act significantly to any of them. The treatments will of course be continued for a further period of years.

The actual manurial treatments, in the first two series are those suggested by Mr. A. H. Burgess, B.Sc., of the S.E.A.College. The underlying idea is to test the comparative value of different forms of Nitrogen and Phosphates, not primarily different quantities of these constituents. This also applies to one of the Potash series.

Thus, taking, for example, the organic nitrogen series, each plot receives the same total quantity of Nitrogen (350 lbs. N. per acre). That nitrogen, however, is given in different forms, such as dung, shoddy, feathers, castor meal and hop bines. All of these are applied in standard quantities but each is analysed annually, and any differences in total nitrogen (below the 350 lbs. N.), are made up by dressings of Sulphate of Ammonia.

In order not to cloud the issue, the other constituents, Phosphates and Potash, are similarly equalised on these plots by dressings of Superphosphate (up to a total of 400 lbs., Phosphate $Ca_3 (P.O._4)_2$ per acre) and Muriate of Potash (up to a total of 200 lbs. Potash K_2O per acre).

The following table shows the actual dressings, based on the analyses of all the manures applied to each Plot (1/3 acre) in the organic nitrogen series in 1924.

1ST SERIES.—SUBSTITUTES FOR DUNG.

Plots 1 *and* 12—"*Dung* 18 *tons per acre.*"	Lbs. N.	$Ca_3(P_2O_4)_2$	K_2O
1½ tons Dung	14.8	23.5	13.1
68.4 lbs. Sulphate of Ammonia ..	14.4	—	—
29.9 lbs. Superphosphate	—	9.8	—
7.3 lbs. Muriate of Potash	—	—	3.6
	29.2	33.3	16.7

Plots 2 *and* 11.—"*Shoddy,* 36 *cwts. per acre.*"			
3 cwt. Shoddy	14.1	—	—
71.7 lbs. Sulphate of Ammonia ..	15.1	—	—
101.5 lbs. Superphosphate	—	33.3	—
34.0 lbs. Muriate of Potash ..	—	—	16.7
	29.2	33.3	16.7

Plots 3 *and* 10.—"*Castor Meal,* 36 *cwt. per acre.*"			
3 cwt. Castor Meal	17.4	—	—
56.1 lbs. Sulphate of Ammonia ..	11.8	—	—
101.5 lbs. Superphosphate	—	33.3	—
34.0 lbs. Muriate of Potash ..	—	—	16.7
	29.2	33.3	16.7

Plots 4 *and* 9.—"*Alternate Dung and Shoddy.*"
Dressing similar to Plots 2 and 11 in 1924.

Plots 5 *and* 8.—"*Feathers,* 18 *cwt. per acre.*"			
1½ cwt. Feathers	18.8	—	—
49.4 lbs. Sulphate of Ammonia ..	10.4	—	—
101.5 lbs. Superphosphate	—	33.3	—
34.0 lbs. Muriate of Potash ..	—	—	16.7
	29.2	33.3	16.7

Plots 6 and 7.—"Hop Bines, 10 cwt. per acre."

66 lbs. Hop Bines	0.3	0.1	0.1
137.4 lbs. of Sulphate of Ammonia	28.9	—	—
102.2 lbs. Superphosphate	—	33.2	—
33.8 lbs. Muriate of Potash	—	—	16.6
	29.2	33.3	16.7

Series 2, which was designed to test the value of different forms of Phosphatic Manures, is conducted on the same principles. Each plot receives a general dressing of Shoddy (2-3 tons per acre), Sulphate of Ammonia (1-2 cwt. per acre), and a general dressing of Muriate of Potash (4 cwt. per acre). The phosphates are supplied in different forms. The actual amount of each phosphatic manure given varies slightly from year to year, on the basis of their analysis, in order to ensure each plot receiving an equivalent amount of Phosphate (400 lbs. $Ca_3(P_2O_4)_2$. If any of the phosphatic manures, on analysis, are found to contain nitrogen, this is balanced on the other plots by equivalent increases in the shoddy dressing.

The different treatments comprised in Series 2 and the approximate annual dressings are as follows :—

Series 2.

DIFFERENT PHOSPHATIC MANURES.

Plots 1 and 12.	Superphosphate, approx. 10 cwt. per acre.			
,, 2 ,, 11.	Dissolved Bone Compound, approx.	12	cwt.	per acre.
,, 3 ,, 10.	Steamed Bone Flour	,,	$5\frac{1}{2}$,,	,,
,, 4 ,, 9.	Phosphatic Guano	,,	7 ,,	,,
,, 5 ,, 8.	Basic Slag	,,	8 ,,	,,
,, 6 ,, 7.	No Phosphate.			

The acre devoted to trials with Potash Manures is divided into two series.

Series 3a is designed to test the effect of giving different quantities of potash. Muriate of Potash is the form used, and the plots are planned as follows :—

Series 3a.—

DIFFERENT QUANTITIES OF POTASH.

Plots 1 and 4.	No Potash.
,, 2 ,, 5.	2 cwt. per acre Muriate of Potash.
,, 3 ,, 6.	6 cwt. ,, ,, ,,

All these plots receive equal dressings annually of Shoddy (2 tons per acre). Sulphate of Ammonia (1-2 cwt. per acre), Superphosphate (6 cwt. per acre), and Steamed Bone Flour (3 cwt. per acre).

Series 3b is laid out for the purpose of testing the relative value of different forms of Potash.

The Plots are as follows:—

Series 3b. DIFFERENT FORMS OF POTASH.

Plots 7 and 10. Muriate of Potash (3 cwt. per acre).
,, 8 ,, 11. Sulphate of Potash (approx. 3 cwt. per acre).
,, 9 ,, 12. Sylvinite (approx. 7 cwt. per acre).

The actual amounts of the two latter dressings are adjusted from year to year, according to analysis, in order to ensure the application of amounts of K_2O equivalent to those in the fixed dressing of Muriate of Potash.

Up to the present no consistent significant differences have appeared in any of our plots.

Part VI

Field Trials

Part VI

CORN TRIALS IN 1924.*

By R. G. HATTON and J. AMOS.

Winter Oats.

As was foreshadowed in our last Annual Report, a special effort has been made this season to improve upon our former methods of conducting Corn Trials by reducing the size of individual plots and by multiplying their number for each variety. Thus instead of having single plots of from half to three quarters of an acre of each variety from which to judge, this year in the case of Winter Oats, plots two drill widths wide of each variety in succession were repeated four times over, so that any soil or other differences would be more likely to be distributed amongst all the sorts under trial. The four plots amounted to slightly over half an acre for each variety.

Cultural Details.

The same five varieties which had been grown in 1922 and 1923 were chosen, the seed again being saved from the previous trials. The trial was conducted on land previously cropped with potatoes for which crop the ground had been manured as follows :—

15 tons of London Dung per acre and 4 cwt. Superphosphate.

1 cwt. Sulphate of Potash and 1 cwt. Sulphate of Ammonia.

After once ploughing and harrowing, the Oats were drilled on October 31st (Series A.) and November 2nd and 3rd (Series B. C. and D.) at the rate of 3½ bushels per acre. A top dressing of 3 cwt. of Superphosphate per acre was given on October 31st, and on April 19th, 1½ cwt. Nitrate of soda. The Oats were once harrowed and twice rolled. At one time, as a result of the very unfavourable seasonal conditions, the oats looked very poor, Marvellous suffering especially from the continued wet weather followed by frosts. It was for this reason that the top dressing of Nitrate of Soda was applied.

The Oats were all cut on 7th and 8th August, and we were very fortunate in being able to thresh all our plots separately straight off the ground, instead of having to stack the twenty plots individually.

Analysis of Results.

In order to show how well worth while the more critical methods proved, the weights of Grain and Straw from each individual plot are given below,

* Reprinted from the Journal of the Kent Farmers' Union, September, 1924.

together with the average weights from all the plots of each variety lumped together.

TABLE I.

Winter Oats. Weight of Total Grain on individual Plots and on the average, shown in lbs. per acre.

Variety.	A.	B.	C.	D.	Average.
Garton's White Winter Oat Marvellous	2112	2294	2435	2600	2360
King's Early Black Wonder ..	2894	2976	2997	3082	2987
Garton's Hardy Prolific Dunn	2224	2706	2118	2018	2267
Webb's New Hardy Black Winter	2894	3165	2706	2847	2903
Garton's New Black Oat Bountiful	2782	2997	3079	3013	2968

TABLE II.

Winter Oats.—Weight of Straw on individual Plots and on the average, shown in lbs. per acre.

Variety.	A.	B.	C.	D.	Average.
White Marvellous	2276	2388	2841	3018	2631
King's Early Black Wonder ..	3459	4294	3824	3835	3853
Grey Dunn	4065	4582	4800	4253	4425
Webb's New Hardy Black Winter	3911	4670	3818	3770	4042
Bountiful	3453	3976	4135	4135	3925

That there is a considerable measure of uniformity will be seen by comparing the actual weight from each plot with the average of the whole, the series of Plots C. and D. illustrate this well. On the other hand, in certain individual instances, the deviation from this average is very considerable, as for instance in the case of Prolific Dunn, Plot B. or White Marvellous, Plots A. and D.

This is shown even more clearly if the actual order of merit of each variety in each series of plots be considered as given below.

TABLE III.

Showing order of merit of Winter Oats judged by yield of Grain on each individual Plot and on the average.

Variety.	A.	B.	C.	D.	Average.
White Marvellous	5	5	4	4	4
King's Early Black Wonder ..	1	3	2	1	1
Grey Dunn	4	4	5	5	5
Webb's New Hardy Black Winter	1	1	3	3	3
Bountiful	3	2	1	2	2

Table IV.

Showing order of merit of Winter Oats judged by yield of Straw on each individual Plot and on the average.

Variety.	A.	B.	C.	D.	Average.
White Marvellous	5	5	5	5	5
King's Early Black Wonder ..	3	3	3	3	3
Grey Dunn	1	2	1	1	1
Webb's New Hardy Black Winter	2	1	4	4	2
Bountiful	4	4	2	2	3

Supposing for instance that these Oats had been judged from the single Series of Plots B., both in the case of Grain and Straw, instead of on the average of the four plots, the actual order of merit would have been very different. Whilst the single plot method *may* give an accurate indication of comparative value, these first year's figures seem to show that the more laborious trials are thoroughly justified.

The following Table gives the average yields of each variety in cwts. and lbs.

Table V.

Winter Oats.—Yield per acre, based on average of four Plots of each.

Variety.	Total Yield. cwt. lbs.	Head Corn. cwt. lbs.	Tail. cwt. lbs.	Nat. weight per bushel in lbs.	cwt. Straw.
King's Early Black Wonder	26 76	25 59	1 17	36¾	34½
Garton's New Black Oat Bountiful	26 53	25 59	106	37	35
Webb's New Hardy Black Winter ..	24 19	22 84	1 47	35	36
Garton's Hardy Prolific Dunn	21 30	19 84	1 58	35¾	39½
Garton's White Winter Oat Marvellous ..	21 7	20 25	94	35¼	23½

If these results be compared with those of 1922 and 1923, the present yields will be found to be an improvement upon those of 1922 but to be considerably below those of 1923.

As to the general order of merit, Prolific Dunn has now for three seasons been one of our poorest yielders of grain, though this year it will be seen to be the heaviest in straw which was very fine and thick, admirably suited for feeding

purposes. For the second season, White Marvellous has also taken a low place. Garton's Bountiful has always maintained second place, but this season King's Early Black Wonder has changed places with Webb's New Hardy Winter Black for first position.

The season was one which was very conducive to the "lodging" of corn, but on our plots, Webb's New Hardy Winter was the only Oat which "went down" to any extent.

WHEAT.

The Wheat Variety Trials were similarly planned, though the Plots here were the width of a single drill, thrice repeated. The results appear equally worthy of some detailed examination.

Cultural Details.

Whilst the best varieties of 1921 and 1922, Starling, Marshal Foch, Yeoman and Fenman, were included, two additional varieties were added, Victor and Rector.

The trial was conducted on land previously cropped with Potatoes, on which the manuring and cultivations were similar to those on the Oat Plot, except that the Wheat received no Spring Dressing of Nitrate of Soda.

The seed of all the varieties, with the exception of Victor, received the same formalin treatment, as a preventive of smut and bunt, before sowing, as was given in our Corn Trials last year. Victor was dressed with Copper Sulphate by the Grower who supplied it, prior to its reception here. No smut or bunt appeared on any Plots. All the seed was drilled at the rate of three bushels per acre on November 5th and 6th. It was cut on August 21st, and threshed straight from the plots on August 28th.

The following Tables give the individual plot weights of grain and straw as in the case of the Oats :—

TABLE VI.

Wheat—Weight of Grain on individual Plots and on the average, shown in lbs. per acre.

Variety.	A.	B.	C.	Average.
Victor	2925	2850	2700	2825
Yeoman	1750	2075	1938	1921
Fenman	2338	2163	2350	2284
Mar. Foch	2588	2388	2325	2434
Starling	2150	1838	2050	2013
Rector	2150	1575	2250	1992

TABLE VII.

Wheat.—Weight of Straw on individual Plots and on the average, shown in lbs. per acre.

Variety.	A.	B.	C.	Average.
Victor	4038	4688	4013	4246
Yeoman	4013	4225	4038	4092
Fenman	4075	4138	4388	4200
Mar. Foch	4813	4513	4025	4450
Starling	3438	3738	3700	3625
Rector	3925	3275	4075	3758

The figures appear generally more uniform than in the case of the Oats, a feature probably explained by the fact that the soil is undoubtedly more even where the Wheat Trials were carried out. Only two adjacent plots, one of Rector, and one of Starling, in Series B. show striking deviations, a fact worth noting since the low place taken by these varieties is partly due to these weak plots.

The general uniformity is even more striking if the order of merit table for the Wheat Varieties given below is studied.

TABLE VIII.

Showing order of merit of Wheat judged by yield of Grain on each individual Plot and on average.

Variety.	A.	B.	C.	Average.
Victor	1	1	1	1
Yeoman	6	4	6	6
Fenman	3	3	2	3
Mar. Foch.	2	2	3	2
Starling	4	5	5	4
Rector	4	6	4	5

There is much less uniformity in the case of the Straw yields :—

TABLE IX.

Shewing order of merit of Wheat judged by yield of Straw on each individual Plot and on average.

Variety.	A.	B.	C.	Average.
Victor	2	1	5	2
Yeoman	4	3	3	4
Fenman	2	4	1	3
Mar. Foch	1	2	4	1
Starling	6	5	6	6
Rector	5	6	2	5

The total crop per acre expressed in cwts. and lbs. is as follows :—

TABLE X.

Wheat Yields per acre

Variety.	Total Corn. cwt. lbs.	Head Corn. cwt. lbs.	Straw. cwt.	Natural Wt. per bushel in lbs.
Victor	25 25	24 49	38	59
Mar. Foch	21 85	20 73	39¾	59¼
Fenman	20 48	19 34	37½	60
Starling	18 0	16 0	32¼	58¼
Rector	17 84	16 58	33½	57½
Yeoman	17 21	14 44	36½	58

Comparing this order with the Seasons of 1921 and 1922, Marshal Foch will be found to have retained its high position, whilst both Starling and Yeoman have been displaced, Fenman for the first time beating both in yield of grain and straw alike.

Mr. C. Bates was responsible for the execution of the experiment and the collection of the data under the superintendance of Mr. J. Amos. This somewhat difficult work was carried out with great care and accuracy. The writers would also like to thank Dr. R. C. Knight for his assistance in analysing and evaluating the above figures.

POTATO TRIALS IN 1924.*

By R. G. HATTON and J. AMOS.

1.—Trial of Varieties.

During the past season, eighteen varieties of Potato have been tested for their cropping qualities. As in the case of our corn trials, we have endeavoured to make these comparative tests more accurate. In order to do this we selected 100 seed tubers of each variety, all of Scotch origin, as nearly as possible of the same grade. In order to check how far we had been successful in so doing, the 100 sets of each variety were then weighed. These weights only varied between the figures 10.5 lb. and 14 lbs., which showed that on the whole we had attained our object.

A half-hundred-weight of each variety was actually grown for trial, but the data here presented are only for the 100 selected sets. They were all grown in closely adjacent rows, on land which had been previously cropped with Winter Oats. This land subsequently received fifteen tons of London Dung per acre, and, at the time of planting, a complete artificial manure, made up as follows, was sown in the drills :—

Superphosphate, 4 cwt. ; Sulphate of Ammonia, 2 cwt. ; Sulphate of Potash, 1 cwt., per acre.

The seed was received in good condition on March 24th. It was immediately " trayed up " and had developed short sturdy sprouts by the time it was planted on April 16th.

All varieties were allowed to mature fully, after being twice sprayed with Bordeaux Mixture (10 ; 6 ; 100), and were lifted on October 13th and 14th. They were similarly graded, the ware being all those tubers which were retained on a $1\frac{5}{8}$ in. riddle ; the seed and chats represent those tubers which passed through the riddle. The seed was selected from the chats by hand grading, so that the personal element entered in to some extent. The object was to keep for seed those tubers which would be retained by a $1\frac{3}{8}$ in. riddle.

Our total yields for the past season, which are given below, were practically double those of 1923, largely owing to seasonal conditions.

* Reprinted from the Journal of the Kent Farmers' Union, November and December, 1924.

	Ware. tons	cwts.	Seed. tons	cwts.	Chats. tons	cwts.	Blights. cwts.	Total yield. tons	cwts.
First Earlies :									
Immune Ashleaf	3	9	3	9	2	9	4	9	11
Epicure	4	7	2	9	1	6	9	8	10
Sharp's Express	3	2	2	10	1	15	12	7	19
Dargill Early	2	15	2	17	1	13	4	7	9
Second Earlies :									
Great Scot	10	13	1	11		14	12	13	10
Ally	8	4	2	5		17	3	11	9
Katie Glover	4	10	2	17	1	16	9	9	12
Arran Comrade	5	0	2	14	1	8	4	9	5
Main Crop :									
Irish Chieftain	13	19	1	6		9	2	15	15
Roderick Dhu	11	12	1	15		14	5	14	5
Majestic	11	19	1	8		12	2	14	0
Kerr's Pink	9	6	1	8		9	49	13	12
Arran Chief	11	3	1	4		9	7	13	3
Tinwald Perfection	7	12	2	19	1	6	7	12	4
Up-to-Date	6	13	1	4		9	73	11	19
King Edward	6	15	2	9	1	3	7	10	13
Crusader	6	18	3	4		19	4	11	5
Bishop	5	0	2	3	1	3	4	8	10

Apart from the total crop weights, the column showing the weights of blighted potatoes seems to point to very definite varietal susceptibilities.

When we come to review the five years trials that have already been undertaken, at first sight the results appear somewhat conflicting. The varieties seem to change their relative positions from year to year. Probably this is due in part to the fact that different conditions of growth and treatment, which they are bound to receive in different seasons, suit particular varieties. Again, the treatment of the seed prior to its reception may quite well be a deciding factor. Finally, the introduction of new varieties for trial and the discarding of others which has taken place each season, make it more difficult to see the true results clearly. This is most obvious in the case of the first earlies, where the varieties of seed sent for trial have changed so often that it is impossible to compare the merits of any two varieties for more than two consecutive years.

In the case of the second earlies and main crop varieties this mistake is sufficiently rectified by the fact that certain standard varieties have been included for at least four years. If these standard varieties such as Great Scot, Ally, Arran Comrade, Majestic, Kerr's Pink, Arran Chief and King Edward be given an "average" place, we find that this indicates a fairly accurate picture of their performance under our conditions. In some cases a variety such as Lochar, although a heavy yielder, has been discarded for some other reason, such as market value. Other varieties were discarded early on in the trials, because they did not appear to have any redeeming features under our conditions.

We publish below the complete list of varieties that have been under trial, together with their "average" places, where they have been tested, sufficiently long.

Position of different Varieties according to Total Crop.

	1919.	1920.	1921.	1923.	Average 1924.	Average place.
First Earlies:						
Dargill Early	4	1	2	2	4	2.6
Arran Rose	2	3	discontinued.	—	—	—
Resistant Snowdrop	1	2	discontinued.	—	—	—
Duke of York	—	—	1	—	—	—
Immune Ashleaf	—	—	—	1	1	—
Ninetyfold	—	4	discontinued.	—	—	—
Sharp's Express	—	—	—	—	3	—
Epicure	—	—	—	—	2	—
Duchess	3	discontinued.	—	—	—	—
Second Earlies:						
Arran Comrade	3	5	1	2	4	3.0
Great Scot	2	3	—	1	1	1.7
Ally	1	4	—	3	2	2.2
British Queen	—	2	—	—	—	—
King George	—	1	2	—	—	—
Katie Glover	—	—	—	—	3	—
Main Crop:						
Majestic	5	1	2	2	3	2.6
Kerr's Pink	1	4	1	3	4	2.6
Irish Chieftain	3	5	—	1	1	2.5
Tinwald Perfection	4	7	—	8	6	6.1
Lochar	2	3	3	discontinued.	—	2.6
Arran Chief	—	2	4	7	5	4.5
Golden Wonder	—	6	discontinued.	—	—	—
King Edward	—	8	—	6	9	7.7
Nithsdale	—	9	discontinued.	—	—	—
Dobbie's Favourite	—	10	discontinued.	—	—	—
Roderick Dhu	—	—	—	(once grown 1st)	2	—
Up-to-Date	—	—	—	3	7	—
Bishop	—	—	—	5	10	—
Lord Ancaster	—	—	—	(once grown 7th)	—	—
Crusader	—	—	—	9	8	—

It hardly seems necessary to include such a list in our future tests. When new varieties of likely merit appear, it would seem to be adequate, if we arrange to compare these with those of already established merit, such as Majestic and Kerr's Pink, Arran Chief and King Edward. We include the two latter because we realise that heavy cropping is not the only recommendation for a variety.

It is, however, interesting to note that in our trials two varieties immune to Wart Disease (Majestic and Kerr's Pink) have proved consistently heavier croppers than the two standard non-immunes (Arran Chief and King Edward).

Two other much-talked-of immune varieties, which we have tried repeatedly, are worth comment. Tinwald Perfection at East Malling has been a consistently poor cropper, though attractive in appearance. Irish Chieftain, though it takes a high place from the point of view of cropping, has the grave drawback of ripening off badly. Here the skin has never hardened. A Potato which we think worth further trial, both from its early cropping performances and quality, is Rhoderick Dhu.

2. Sources of Seed.

In 1920 and 1921 trials of source of seed were conducted and, in both cases, the very general superiority of Scotch Seed over " Once Grown " was emphasised. In 1920, Scotch Seed gave heavier yields in six cases out of ten, and in 1921, in seven cases out of eight. However, in neither of these years was the superiority of the seed so startlingly marked as in the past season. In fourteen cases out of fifteen the crop grown from Scotch seed has been much heavier. In the vast majority of cases the yield is nearly double the total crop of the once grown seed, and a much higher proportion of " ware " tubers are found. In the case of the first earlies however the beneficial results of planting " once grown " seed is well illustrated in the much higher proportion of ware sized tubers obtained from the home seed, though the Scotch seed yields almost as heavy or even heavier total crops. We first pointed to this fact in 1921 and 1922. In nine cases also there are considerably fewer blighted potatoes from the Scotch seed, though with two varieties, Up-to-date and Kerr's Pink, this result is strikingly reversed.

The once grown seed this season was noted to be suffering from a severe attack of leaf curl and " mosaic," which doubtless accounted to a large extent for the very striking differences ; yet this seed had been saved from apparently healthy well-grown plants in 1923.

In the past season we only included seed of one variety from another source than Scotland. We tested King Edward seed from Lincolnshire, with the result that we obtained the heaviest crop from this seed. This fact will at least serve as a reminder of our previous results in 1920 and 1921, when we tested seed from Scotland, Ireland, Cumberland and Lincolnshire, and shewed that we might reasonably hope to get good results from changes of seed from other sources besides Scotland. It may be recalled that seed from Cumberland twice shewed outstanding promise.

These reflections may serve as a warning in a year when seed is dear and scarce, and one is tempted to save ones own. Except in the case of first earlies, we could not recommend it, under conditions such as ours. But if Scotch seed

is unobtainable, it should still be worth trying to purchase good seed grown under other soil and climatic conditions.

The following Table gives the actual comparative yields per acre from Scotch (S.) and Once Grown (H.), seed this year. Lincolnshire (L.) :—

		Total. tons. cwts.	Ware. tons. cwts.	Seed. tons. cwts.	Blights. tons. cwts.
First Earlies :					
Immune Ashleaf ..	S.	9 11	3 9	3 9	– 4
	H.	8 10	4 8	2 3	– 9
Dargill Early	S.	7 9	2 15	2 17	– 4
	H.	7 18	5 2	1 15	– 4
Second Earlies :					
Great Scott	S.	13 10	10 13	1 11	– 12
	H.	7 11	5 2	1 4	– 11
Ally	S.	11 9	8 4	2 5	– 3
	H.	5 0	2 19	1 1	– 8
Arran Comrade ..	S.	9 6	5 0	2 14	– 4
	H.	6 7	3 14	1 7	– 9
Main Crop :					
Irish Chieftan	S.	15 16	13 19	1 6	– 2
	H.	5 14	3 16	– 14	– 12
Roderick Dhu	S.	14 16	11 12	1 15	– 5
	H.	8 1	5 9	1 6	– 14
Majestic	S.	14 1	11 19	1 8	– 2
	H.	8 9	6 8	1 4	– 5
Kerr's Pink	S.	13 12	9 6	1 8	2 9
	H.	7 6	3 1	1 8	1 18
Arran Chief	S.	13 3	11 3	1 4	– 7
	H.	6 9	4 10	– 19	– 9
Tinwald Perfection ..	S.	12 4	7 12	2 19	– 7
	H.	5 17	3 9	1 1	– 11
Up-to-Date	S.	11 19	6 13	1 4	3 13
	H.	10 8	6 13	– 17	2 7
King Edward	L.	11 16	8 8	1 1	– 5
	S.	10 14	6 15	1 3	– 7
	H.	6 12	4 5	– 17	– 4
Crusader	S.	11 5	6 18	3 4	– 4
	H.	4 16	2 5	– 16	– 11
Bishop	S.	8 10	5 –	2 3	– 4
	H.	8 –	5 12	1 8	– 4

3. Treatment of Seed.

Cut Sets v. *whole Sets.*

Last season we conducted an experiment to test the effect on the yield of certain varieties by using cut sets instead of whole sets. In 1923, the practice of using cut sets after exposure to light proved distinctly detrimental in the cases of Bishop and Majestic, but much less so with King Edward.

The same experiment was repeated this year, of course under very different seasonal conditions. In three cases out of four, the results obtained in 1924 confirm those of 1923, though for some reason Majestic did not show the ill-effects of cut and exposed seed this year. The following are the actual average yields per hill.

Yield per Hill.

	Cut and exposed.	Cut and protected.	Whole set.
King Edward.. ..	30 ozs.	33 ozs.	32 ozs.
Bishop..	24	20	29
Eclipse	36	34	42
Majestic	35	35	35

Though the results this year are not quite so regular or striking, if they are taken in conjunction with those published a year ago, they seem to afford sufficient evidence to warrant a general warning against the use of cut sets.

RUNNER BEAN TRIALS IN 1924.

By H. C. CHAPELOW.

During the Summer of 1924, Trials with Runner Beans were initiated with three main objects in view.

First, to establish a standard of recognition for the main classes of Runner Bean and to test the trueness to type of varieties in circulation under given names.

Second, to make a preliminary cropping test of the relative values of different varieties under our conditions.

Third, to test the method of training the plants upon poles against the common commercial practice of keeping them dwarf by nipping out the growing tips.

To achieve our first object, the establishment of recognisable groups, our collection was almost entirely confined to some of the chief market varieties. Five well-known Seedsmen were invited to give a list of the principal market sorts and to supply seed of the same. With their ready co-operation some thirty-seven collections were got together. These were grouped as far as possible, and single rows of each twenty feet long, were planted on May 12th. All those collections received under a single name were planted as close together as possible, so as to render comparison easy. They were all trained on seven-foot poles to enable them to exhibit their normal characteristics of growth and bearing.

The plots were kept under close observation throughout the summer, and a considerable amount of data collected therefrom. Each variety was carefully "rogued" in order to detect differences in flower and vegetative characters. In addition, measurements of pod lengths, counts of the number of seeds contained and of the number of pods per pound were taken at the first, third and last pickings.

The total crop weights from these short rows were also kept in order to compare them with the more exhaustive variety trials, separately arranged.

The collections were placed from their names into the following eight groups :

Scarlet Runner.
Scarlet Emperor.
Ne Plus Ultra.
Gertford Giant.
Painted Lady.
Marvel or Improved Painted Lady.
White Runner.
Czar.

Before discussing the group character and trueness of type of these classes, it may be worth making a few comments upon the different features on which notes were made, and their apparent utility, as assisting in roguing operations and serving as a basis for the identification of varieties.

(*a*) *Colour and Markings of Seed.*

Efforts to identify different varieties of Runners from seed were only partially successful. Whilst it was possible to separate widely divergent groups such as Whites, Reds, Painted Ladies, etc., quite easily, it has not yet been possible to separate closely allied groups such as White Runner and Czar.

(*b*) *Flowers.*

One of the easiest and most certain methods by which it was possible to distinguish the main groups, was by flower-colour and size, but here again closely allied groups were not readily separated.

(*c*) *Pods.*

Although not so obvious a guide as flower colour, the length, breadth and texture of the pods appeared fairly constant in the various groups, and might apparently even serve as a basis for separating the more nearly allied varieties. Characters connected with the pods, however, are for obvious reasons, not so useful as flower characters in roguing impure stock.

(*d*) *Leaves.*

Beyond the very large differences, such as those of size between the Scarlet Runner and Emperor Group, leaf characters afforded very little aid in separating the groups.

(*e*) *Stems.*

Next to colour of the flowers, colour and markings of stems were found to be the most constant features in distinguishing the various groups.

(*f*) *Growth.*

Considerable differences were noticed in the relative vigour of the different types, but these proved to be of very little use for classification purposes.

With a few outstanding exceptions, it was encouraging to find that, in the main, the named varieties fell indisputably into their class. These classes have of course certain recognised features such as flower colour, type of pod, etc., but, in order that our classes may be easily recognised, a few very general notes are given as to these characteristics, as they were apparent in our collections, before discussing the tabulated results.

A.—Scarlet Runner Class.

Seed: Parti-coloured, pink, tinted buff and black.
Flowers: Scarlet.
Stems and Leaves: Stems, dark green, tinged purple; leaves, light to medium green.
Pods: About 5½ ins long, medium breadth, smooth texture.

B.—Scarlet Emperor Class.

Seed: Parti-coloured, pink, tinted buff and black.
Flowers: Scarlet.
Stems and Leaves: Stems, dark green tinged purple; leaves, medium green, larger than the A. Class.
Pod: Length about 7½ in., much broader than the A. Class, coarse texture.

C.—Ne Plus Ultra Class.

Seed: Parti-coloured, red, tinted buff and black.
Flowers: Scarlet.
Stems and Leaves: Stems, dark green; leaves, dark green of average size.
Pods: Length, about 7 ins., rather narrow and plump, smooth texture.

D.—Gertford Giant Class.

Seed: Parti-coloured, pink tinted buff with a small area of black.
Flowers: Dark scarlet.
Stems and Leaves: Stems, very dark green; leaves, large and dark green.
Pods: Length, about 6 ins., medium breadth, medium texture.

E.—Painted Lady Class.

Seed: Parti-coloured, light buff and brown.
Flowers: Pink and white.
Stems and leaves: Medium green.
Pods: 6 ins. long, medium breadth, smooth texture.

F.—Marvel, Giant or Improved Painted Lady Class.

Seed: Parti-coloured, light buff and brown.
Flowers: Pink and white.
Stems and Leaves: Medium green, with larger leaves than the Painted Lady Class.
Pods: Length from 5.5 ins. to 7.7 ins. (see Table I. Nos. 33-37). Of medium breadth, medium to coarse in texture.

G.—White Runner Class.

Seed : White.
Flowers : White.
Stems and Leaves : Light green.
Pods : About 5 ins. long, medium breadth, smooth texture.

H.—Czar Class.

Seed : White.
Flowers : White.
Stems and Leaves : Light green.
Pods : About 6 ins. long, rather broad, coarse texture.

The following table shows that, in the case of pod characters, the features of a single named variety, collected from different sources, were on the whole encouragingly constant. Where, here and there, a single sample in any one group gave pods of exceptional size, it was generally because it did not in reality belong to that group, but would more accurately be placed in another class.

The outstanding exceptions in their classes are of course the Scarlet No. 6, the Ne Plus Ultra without purple pods, the Giant and Improved Painted Ladies, Nos. 33 and 35, respectively, the White Runner, No. 21, and the White Emperor, No. 24.

No. 6 has undoubtedly showed the characteristics of the Emperor Class rather than those of the Runner Group.

However, in several of the other outstanding cases it was quite impossible in a single season to determine whether they were merely selected stocks or improved strains, or whether they were distinct varieties which should be placed in another class. At any rate this analysis of pod characteristics seems sufficiently promising to warrant its further trial as a method of separating named varieties.

It is interesting to note that in these short twenty-foot rows only eight out of the twenty-seven collections showed obvious " rogue " plants ; yet, that, apart from the too small group of Gertfords, the White Classes were the only ones apparently wholly pure. In three of these cases as many as 6 per cent. of the plants were different from the bulk.

As the seed was so carefully scrutinised at sowing, it can confidently be stated that in any one numbered collection no obviously differing seed was planted. This careful selection of seed was not only undertaken for our short rows but for the larger cropping trials where 2,200 seeds of each group were sown. The results of " roguing " these larger areas are perhaps worth tabulating, as they seem to suggest that work might profitably be extended into a study of the heredity of the Runner Bean.

TABLE I.

Showing Pod Characters of Groups of Runner Beans.

Source of Stock.	Name sent under.	Av. length of pods in ins.	Av. No. of seeds per pod.	Av. No. per lb.	% Obvious "rogues."	Remarks.
No.						
1	Scarlet Runner	5.5	3.0	31	0	
2	" "	5.4	2.6	33	0	
3	" "	5.5	3.1	32	3	
4	" "	5.1	3.3	32	3	Some pods tinged purple.
5	" "	5.8	3.2	32	6	
6	" "	8.9	5.3	17	0	Foliage and pods resemble Emperor
Average (omitting 6)		**5.5**	**3.3**	**32**		class.
7	Scarlet Emperor	7.7	4.6	23	0	
8	" "	8.0	4.6	21	0	
9	" "	7.3	4.4	22	0	
10	" "	7.6	5.3	20	0	
11	" "	6.5	4.1	25	6	
12	" "	6.5	4.1	26	0	
Average		**7.3**	**4.5**	**22.8**		
13	Ne Plus Ultra	7.3	4.5	30	3	Some pods purple edged.
14	" " "	6.6	4.2	21	0	Ditto.
15	" " "	7.3	4.1	22	0	None ditto.
16	" " "	6.7	4.7	25	0	Many pods
Average		**6.9**	**4.2**	**24.5**		purple edged.
17	Gertford Giant	6.4	3.9	25	0	
18	" "	5.3	3.7	28	0	
Average		**5.8**	**3.8**	**26.5**		
29	Painted Lady	6.6	4.0	20	3	
30	" "	7.2	4.6	23	0	
31	" "	6.1	4.1	27	0	
32	" "	5.1	3.3	31	6	
Average		**6.2**	**5.0**	**25.3**		
33	Giant Painted Lady	8.4	4.6	17	0	
34	Marvel ditto	5.0	3.7	36	0	
35	Improved ditto	7.0	4.7	21	0	
36	Marvel ditto	6.0	3.8	33	0	
37	Marvel ditto	5.5	3.9	35	3	
Average (omitting 33 and 35)		**5.5**	**3.7**	**34.6**		
19	White Runner	5.3	3.3	29		
20	" "	5.2	3.2	28	0	
21	" "	7.1	4.6	21	0	
22	" "	5.3	3.2	28	0	
23	" "	5.0	2 9	29	0	
Average (omitting 21).		**5.2**	**3.2**	**28.5**	0	
24	White Emperor	8.1	4.8	16		
25	Czar.	5.9	3.7	26	0	
26	"	6.6	4.0	21	0	
27	"	5.9	3.5	25	0	
28	"	6.4	4.1	22	0	
Average (omitting 24).		**6.2**	**3.8**	**23.5**	0	

		Red Flowered.	Painted Lady Type (parti-coloured).	White Flowered.
Scarlet Runner ..	(No. 6)	2163	3	34
Scarlet Emperor ..	(No. 10)	2199	0	1
Ne Plus Ultra ..	(No. 14)	1198	1	1
,, ,, ,, ..	(No. 13)	1197	0	3
Gertford Giant ..	(No. 18)	1189	3	8
,, ,, ..	(No. 17)	998	1	1
Painted Lady ..	(No. 32)	105	1999	96
Marvel Painted Lady	(No. 37)	77	2120	3
White Runner ..	(No. 23)	3	0	2197
Czar	(No. 28)	0	0	2200
,, ...	(No. 27)	0	0	2200

In cases like Scarlet Runner, No. 6, Gertford Giant, No. 18, etc., showing white and parti-coloured types, the seed was very carefully examined, so that it is quite impossible for any white or brown and buff-coated seeds to have been sown with them.

It seems obvious that from some cause many of our commercial stocks are not pure lines, though few of those received by us were from an economic point of view seriously mixed. On the other hand, the sources from whence our seed came were of the very best. It would be interesting on some future occasion to take an even wider survey.

Cropping Trials.

Although the cropping trial of different varieties was not in any sense ideal, since the seed, in many cases, had to be collected from different sources, and almost certainly had been harvested under different conditions, yet it has been decided to give the results for what they are worth.

If they serve no other purpose, they will illustrate the sort of variation which may be expected in such trials from plot to plot. If the results of these larger and quadruplicated trials be compared with that of the same varieties in the single twenty-feet rows, they afford but one more example of the danger of the " single plot " experiment.

The main cropping trials occupied in all about one acre of ground, two rather differently treated half acres being available for the purpose. The one site was a piece of ground which had been heavily manured the previous season in preparation for planting hops and the other consisted of the open twelve foot alleyways between rows of Maiden Apple trees. This latter piece of land had never been so generously manured as the former.

Each variety was repeated three times between the rows of Maiden Apple trees, and once upon the hop garden site, in rows approximately 300 feet long. An identical number of seeds was sown in each row.

All varieties were treated alike and grown as "dwarfs," by the pinching out of the tips at intervals during the season. The whole commercial crop was picked and weighed off each plot separately. The results are tabulated below.

TABLE II.

Crop weight in lbs. of Varieties of Runner Beans in Plots of $\frac{1}{32}$ acre each.

Name.		Plot. A.	B.	C.	D.*	Average.	Order.	Order in 20 foot row trial.
Scarlet Runner	(6)	276	269	347	361	313	5	1
Scarlet Emperor	(10)	262	235	314	319	282	8	5
Ne Plus Ultra	(14)	323	305	243	435	326	3	2
Gertford Giant	(18)	311	282	366	423	345	2	6
Painted Lady	(32)	364	305	340	291	300	7	3
Marvel P.L.	(37)	337	301	376	372	346	1	6
White Runner	(23)	285	294	361	293	308	6	3
Czar	(28)	30-	247	345	390	321	4	8

* Row D is on the more heavily manured land.

Until we have managed to obtain seed of our chief varieties harvested under comparable conditions, and have repeated the trials, we do not want to stress the comparative results, but the almost complete reversal of the "single row" results by the quadruplicate plot results is well worth remembering. That there are considerable differences in yield appears more than likely, but when the high position of a variety such as Ne Plus Ultra in our trials may depend largely upon the exceptional yield of one out of four plots, it is impossible to draw definite conclusions at this early stage.

However, enough has been done to prove that these trials are worth continuing.

CULTURAL METHODS.

The final object of these Trials was to discover the best cultural methods. The effect of dwarfing the plants by pinching out the heads at intervals during the growing season was tested against the growing of the beans on poles, thus allowing them to reach their full normal development.

The ground (approx. $\frac{1}{2}$ acre), was divided into six equal plots. The treatments were applied to three varieties, and the plots were each repeated three times. Below will be seen the effects of both methods on the crop, throughout the picking season.

Table III.

Comparison of Yield from "Trained" and "Pinched" Plants throughout Season.

	July 22.		July 31.		Aug. 12.		Aug. 20.		Aug. 28.		Sept. 18.		Total.	
	Trained on poles.	Pinched and dwarfed.	Trained.	Pinched.	Trained.	Pinched.	Trained.	Pinched.	Trained.	Pinched.	Trained.	Pinched.	Trained.	Pinched.
Scarlet Emperor	3	22	24	60	195	194	132	132	94	111	429	280	877	799
White Runner	2	19	18	39	132	144	206	131	149	94	443	255	950	682
Marvel, Painted Lady	8	27	65	60	193	131	181	122	81	54	452	152	980	546
Totals, Month by Month	13	68	107	159	520	469	519	385	324	259	1324	687	2807	2027

The effect of staking the plants has increased the crop very considerably. Both White Runner and Painted Lady, two of the varieties employed, showed respectively 268 lbs. and 434 lbs. increase in total crop. While the total crop picked off the dwarfed plants considerably exceeded that picked from those on the poles for the first two pickings, the total from the dwarfed plants did not exceed that picked from the poled plants on any occasion subsequently.

The question of obtaining early Beans may however be as important as that of total yield, and the pinching has most decidedly had the effect of producing early beans.

Part VII.

Meteorological Observations.

Part VII.

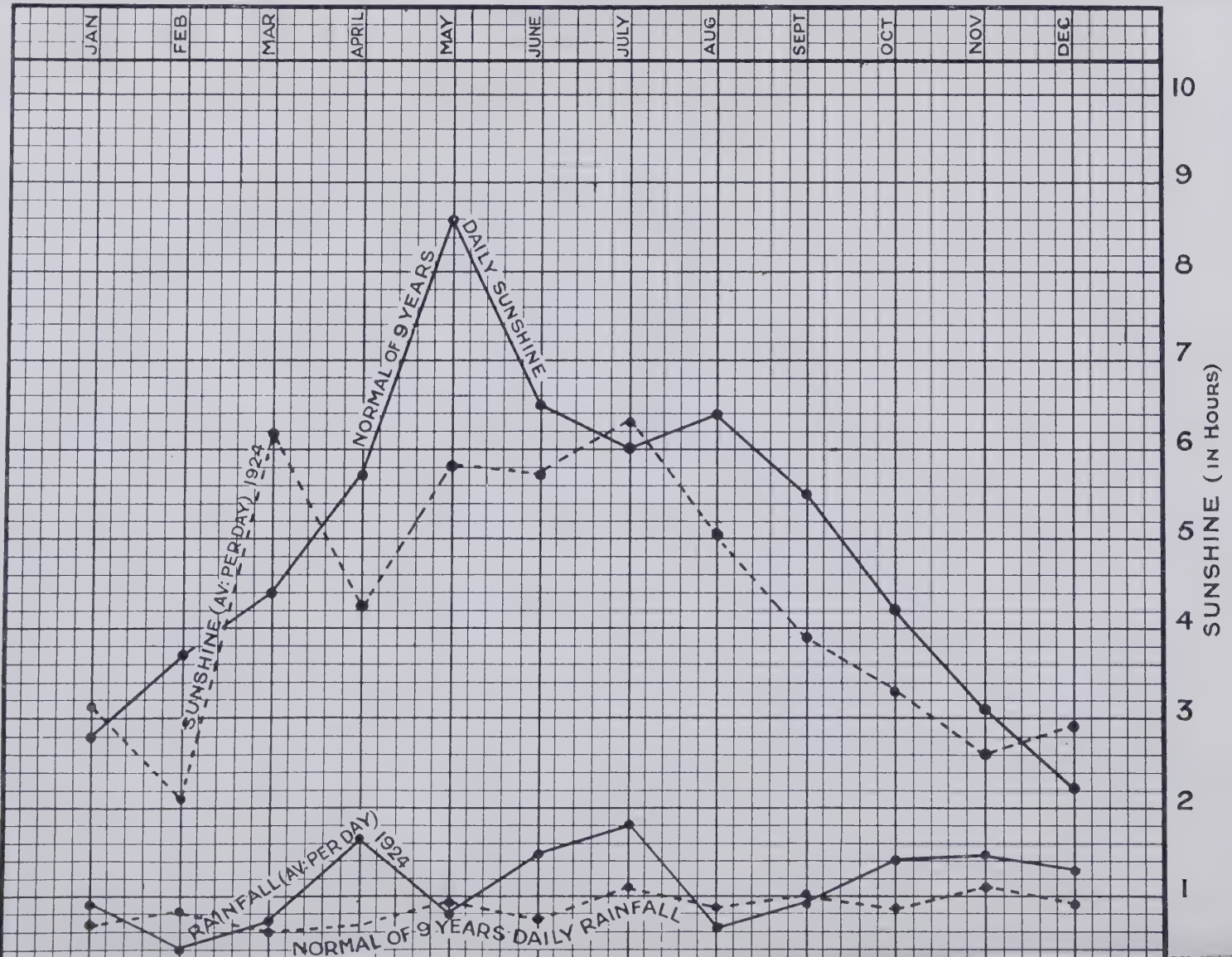
METEOROLOGICAL OBSERVATIONS.

WEATHER CONDITIONS DURING 1924.

By H. M. TYDEMAN.

The weather experienced at this Station during the past year might be characterised as somewhat wet and dull. The total rainfall of the year of 30.92 inches was 6.7 inches in excess of our normal yearly rainfall; and, of the twelve months, nine had a rainfall in excess of the normal. Sunshine on the other hand, was deficient and the 1,293 hours of sunshine recorded here during the year were just 106 hours short of the average annual sunshine of the previous nine years. Only March, July and December had sunshine in excess of the normal, while February, September and November were notably deficient. The temperature however departed little from the normal and neither excessively warm nor excessively cold periods were experienced.

TABLE SHOWING SUNSHINE AND RAINFALL DURING 1924 (AVERAGE PER SUNNY OR RAINY DAY) COMPARED WITH PREVIOUS NINE YEAR AVERAGE.



SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1924.

	Barometer.	Temperature in Screen.					On Grass.		No. of Frosts.	Rainfall.				Sunshine.			Hygrometers.			Wind.
	Mean reading.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Mean.	Mean.	Lowest.		Total (ins.)	No of days.	Av. per rainy day.	Heaviest fall in a day.	Total hours.	No. of days	Av. per sunny day.	Mean of dry bulb.	Av. deprec. of wet bulb.	Av. humidity. %	Prevailing direction.
January ..	29.887	45.4	37.5	51.7	26.0	41.4	31.5	16.0	11	2.39	14	0.17	0.44	43.1	14	3.1	40.4	1.0	91	S.W.
February ..	29.880	42.0	32.5	49.7	24.9	37.2	28.6	12.3	16	0.60	8	0.075	0.2	33.5	16	2.1	37.4	1.6	85	N.W.
March	29.816	48.2	31.4	56.5	21.7	39.8	25.8	15.0	23	1.14	8	0.14	0.26	166.3	27	6.2	39.7	2.5	77	S.E.&N.E.
April	29.778	53.3	38.5	70	21	45.9	33.3	17.0	10	3.31	10	0.33	0.79	110.3	26	4.2	46.9	3.4	74	N.E. & E.
May	29.836	63.4	46.7	77	36	55.0	42.3	28.0	1	2.21	14	0.16	0.46	181.5	31	5.8	57.5	2.0	88.8	S.W.
June	29.938	66.8	49.6	78	39	58.2	46.2	34.5	0	2.03	7	0.29	0.6	166.3	29	5.7	60.0	5.0	71.8	E. & S.E
July	29.839	70.2	49.6	85	39	59.9	46.2	39.0	0	2.99	8	0.37	0.85	183.3	29	6.3	62.7	5.3	72	S.W.
August	29.768	67.1	48.4	75	41	57.7	45.7	38.0	0	1.90	15	0.13	0.3	156.3	31	5.0	60.5	4.2	75	W. & S.W.
September ..	29.775	63.6	48.7	71.5	36	56.1	45.9	33.2	0	3.75	19	0.19	0.65	93.3	24	3.9	58.3	3.0	82	S.W.
October ..	29.849	58.3	43.0	67.0	29	50.7	40.2	23.0	5	3.93	14	0.28	0.72	76.3	23	3.3	52.2	2.2	85	E.
November ..	30.012	50.7	36.3	59.5	20.7	43.5	35.3	18.0	8	3.2	11	0.29	0.86	36.2	14	2.6	45.5	2.0	84	E.
December ..	29.927	49.2	36.4	65.0	25.0	42.8	34.16	18.0	11	3.47	14	0.25	0.63	47.0	16	2.9	42.8	1.2	90	S. & S.W.

TITLE.	JOURNAL OF PUBLICATION.	REPRINTS.
POMOLOGY.		
Top Fruits.		
Root Stocks.		
Paradise Apple Stocks. By R. G. Hatton.	Journal of Royal Horticultural Society, Vol. xlii., Part 2 and 3, p. 361, September, 1917.	
Paradise Apple Stocks. Their Fruit and Blossom described. By R. G. Hatton.	Ditto, Vol. xliv., p. 89, May, 1919.	
Suggestions for the Right Selection of Apple Stocks. By R. G. Hatton.	Journal of Royal Horticultural Society, Vol. xlv., Parts 2 and 3, p. 257, July, 1920.	
A First Report on Quince Stocks for Pears. By R. G. Hatton.	Journal of Royal Horticultural Society, Vol. xlv., Parts 2 and 3, p. 269, July, 1920.	
Results of Researches on Fruit Tree Stocks. By R. G. Hatton.	Journal of Pomology, Vol. ii., No. 1, pp. 1-10, November, 1920.	
Stocks for the Stone Fruits. By R. G. Hatton.	Journal of Pomology, Vol. ii., No. 4, pp. 209-245, August, 1921.	Price 1s. 6d., postage 3d.
The Importance of Suitable Stocks in Planting Young Fruit Trees. By R. G. Hatton.	Journal of the Kent Farmers' Union, Vol. x., No. 3, p. 82, September, 1921.	
The Influence of Root Stock upon the Tree Fruits. By R. G. Hatton.	Fruit Grower, Vol. xvi., No. 1455, pp. 639-641; No. 1456, pp. 699-700; No. 1457, pp. 759-760; 18th and 25th October, 1923, and 1st. November, 1923. Verslag Van Het International Tuinvouw-Congress, Amsterdam, 17th-23rd September, 1923, pp. 94-117.	Price 6d., postage 2d.
Some Notes on Stocks for Plums. By R. G. Hatton.	Journal of the Kent Farmers' Union, Vol. xiv., No. 5, p. 158, November, 1923.	
Cherry Stocks; their Behaviour in the Nursery. By N. H. Grubb and A. W. Witt.	Annual Report of the East Malling Research Station, 1924, pp. 87-92.	
The Choice of Young Fruit Trees. By R. G. Hatton, J. Amos and N. H. Grubb.	Journal of the Kent Farmers' Union, Vol. xvi., No. 4, pp. 132-134, October, 1924, and Annual Report of the East Malling Research Station, 1924, pp. 93-100.	

TITLE.	JOURNAL OF PUBLICATION.	REPRINTS.
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Summary of the Results obtained in Selecting and Propagating Paradise Stocks. By R. G. Hatton.	The Fruit Grower, Vol. xlvii., pp. 1211-1212, February, 1919; Fruit Trades' Journal, Vol. xxxv., Nos. 7, 8, 9, February, 1919; Gardeners' Chronicle, Vol. lxv., Nos. 1677, 1678, 1679, pp. 71, 82, 100, February and March, 1919.	
Some Problems of Propagation, Part I. By R. G. Hatton, J. Amos and A. W. Witt.	Annual Report of the East Malling Research Station, 1923, pp. 100-109.	
Pruning.		
Results of Apple Pruning Experiments. By N. H. Grubb.	Journal of the Kent Farmers' Union, Vol. x., No. 4, p. 114, October, 1921.	Price 3d., postage 1d.
Winter Pruning Experiments with Apple Trees. By N. H. Grubb.	Journal of Royal Horticulturel Society, Vol. xlvii., Parts 2 and 3, p. 139, September, 1922.	Price 6d., postage 2d.
Notes on Apple Pruning. By N. H. Grubb.	Journal of the Kent Farmers' Union, Vol. xiii., No. 3, p. 95, March, 1923.	Price 3d., postage 1d.
Apple Pruning. Summary of Deductions from Experiments at East Malling. By N. H. Grubb.	Journal of the Kent Farmers' Union, Vol. xviii., No. 5, pp. 150-154, November, 1925.	Price 2d.
Miscellaneous.		
Some Factors Influencing Root Development. By R. G. Hatton, N. H. Grubb and J. Amos.	Annual Report of the East Malling Research Station, 1923, pp. 110-119.	
Field Observations on the Incidence of Leaf Scorch upon the Apple. By R. G. Hatton and N. H. Grubb.	Journal of Pomology and Horticultural Science, Vol. iv., No. 2, pp. 65-77, January, 1925.	Price 6d.
	Annual Report of the East Malling Research Station, 1924, pp. 41-53.	
Some Factors Influencing the Period of Blossoming of Apples and Plums. By R. G. Hatton and N. H. Grubb.	Annual Report of the East Malling Research Station, 1924, pp. 81-86.	
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Black Currant Varieties—A Method of Classification. By R. G. Hatton.	Journal of Pomology, Vol. i., Nos. 2 and 3, pp. 65-80, 145-154, 1920.	
The "Running-Off" of Black Currants. By R. Wellington, R. G. Hatton and J. Amos.	Ditto, Vol. ii., No. 3, pp. 160-198, May, 1921.	

TITLE.	JOURNAL OF PUBLICATION.	REPRINTS.
Black Currant Variety Trials—Reliability of Results. By R. G. Hatton, N. H. Grubb and R. C. Knight.	Journal of Pomology and Horticultural Science, Vol. iv., Nos. 3 and 4, pp. 200-220, June, 1925.	Price 6d.
Commercial Raspberries and Their Classification. By N. H. Grubb.	Journal of Pomology and Horticultural Science, Vol. iii., No. 1, pp. 11-35, November, 1922.	Price 7d., postage 3d.
*A Note on the Impurity of Raspberry Stocks. By N. H. Grubb and G. S. Peren.	Ditto, Vol. iii., No. 1, pp. 7-10, November, 1922.	
Raspberry Investigations. By N. H. Grubb.	Annual Report of the East Malling Research Station, 1923, pp. 128-130.	
Raspberry Varieties and Their Cropping. By N. H. Grubb.	Ditto, 1924, pp. 75-80.	
PHYSIOLOGY.		
The Carbohydrate-Nitrogen Ratio. By R. C. Knight.	Science Progress. Vol. xix., pp. 34-42, 1924.	
PATHOLOGY.		
Tests of Fungicides on Apple Trees. By N. H. Grubb.	Journal of Pomology, Vol. ii., No. 2, pp. 93-114, February, 1921.	
Tests of Fungicides on Apple Trees—II. By N. H. Grubb.	Ditto, Vol. iii., No. 4, pp. 157-173, January, 1924.	
Fungicidal Spraying of Apples. By N. H. Grubb and N. B. Bagenal.	Annual Report of the East Malling Research Station, 1923, pp. 120-124.	
Experiences with Fungicidal Sprays. By N. H. Grubb.	Journal of the Kent Farmers' Union, Vol. ix., No. 5, p. 147, May, 1921.	
The Spraying of Apples. By N. H. Grubb.	Gardeners' Chronicle, Vol. lxx., No. 1826, p. 326, December, 1921.	
The Crown Gall Disease of Nursery Stocks I. Field Observations on Apple Stocks. By H. Wormald and N. H. Grubb.	Annals of Applied Biology, Vol. XI, Nos. 3 and 4, pp. 278-291, October, 1924.	
Notes on the Control of Nursery Stock against Crown Gall. By H. Wormald and N. H. Grubb.	Gardeners' Chronicle, Vol. lxxi., No. 1843, p. 198, April, 1922.	
Field Observations on the Crown Gall of Nursery Stocks. By H. Wormald and N. H. Grubb.	Annual Report of the East Malling Research Station, 1924, pp. 122-125.	

TITLE.	JOURNAL OF PUBLICATION.	REPRINTS.
The Blue Stripe Wilt of the Raspberry. By R. V. Harris.	Journal of Pomology and Horticultural Science, Vol. iv., Nos. 3 and 4, pp. 221-229, June, 1925, and Annual Report of the East Malling Research Station, 1924, pp. 126-134.	Price 6d.
Raspberry "Mosaic." By N. H. Grubb and A. M. Massee.	Annual Report of the East Malling Research Station, 1923, pp. 131-133.	
†The Mulberry Blight in Britain. By H. Wormald.	Annals of Applied Biology, Vol. xi., No. 2, pp. 169-174, July, 1924.	
Mulberry Bacterial "Blight." By H. Wormald.	Annual Report of the East Malling Research Station, 1924, pp. 120-121.	
An Unusual Form of Pear Canker. By R. V. Harris.	Ditto, 1924, pp. 135-136.	
Note on the Bacterial Soft Rot of Turnips. By H. Wormald and R. V. Harris.	Annals of Applied Biology, Vol. xii., No. 3, pp. 326-329, July, 1925.	
Notes on Plant Diseases in 1924. By H. Wormald.	Annual Report of the East Malling Research Station, 1924, pp. 110-119.	
For Potato Spraying. See Field Trials.		
Parasitic Fungi of Cereals. By H. Wormald.	Farm Crops, Vol. I., pp. 318-336, 1925.	
ENTOMOLOGY.		
The Control of the Apple Blossom Weevil. By A. H. Massee.	Journal of Pomology, Vol. iv., No. 1, pp. 59-61, July, 1924.	Price 5d.
Control of Apple Blossom Weevil. By R. G. Hatton.	Journal of the Kent Farmers' Union, Vol. ix., No. 6, p. 176, June, 1921.	
Apple Blossom Weevil Experiments. By K. P. Worsley.	Journal of the Kent Farmers' Union, Vol. xii., No. 1, p. 30, July, 1922.	
The Resistance of Apple Stocks to Attacks of the Green Apple Aphis. By A. M. Massee.	Journal of Pomology, Vol. iii., No. 4, pp. 191-200, January, 1924.	
The Control of the Big Bud Mite in the Field. By R. G. Hatton, J. Amos and H. M. Tydeman.	Annual Report of the East Malling Research Station, 1924, pp. 158-160.	
The Control of Big Bud Mite in the Field. By H. M. Tydeman.	Annual Report of the East Malling Research Station, 1923, pp. 125-127.	
The Leaf and Bud Mite of Raspberry. By A. M. Massee.	Journal of Pomology, Vol. iv., No. 1, pp. 59-61, July, 1924.	
Abnormal Leaves of the Himalaya Berry and the Raspberry. By A. M. Massee.	The Gardeners' Chronicle, Vol. lxxii., No. 1872, p. 281, November 11th, 1922.	

TITLE.	JOURNAL OF PUBLICATION.	REPRINTS.
Raspberry " Mosaic " (see Pathology Section).		
Preliminary Field Trials of Tar Distillate Washes. By A. M. Massee.	Annual Report of the East Malling Research Station, 1924, pp. 143-144.	
HOPS.		
First Report on Trial of New Varieties of Hops at East Malling. By Prof. E. S. Salmon.	The Research and Advisory Dept., S.E.A. College, Wye, January, 1918.	
Second Ditto. By Prof. E. S. Salmon.	Ditto, April, 1919.	
Third Ditto. By Prof. E. S. Salmon.	Ditto, April, 1920.	Price 6d., postage 2d.
Fourth Ditto. By Prof. E. S. Salmon.	East Malling Research Station, Kent, July, 1921.	Ditto.
Fifth Ditto. By Prof. E. S. Salmon.	Ditto, July, 1922.	Ditto.
Sixth Ditto. By Prof. E. S. Salmon.	Ditto, July, 1923.	Ditto.
Seventh Ditto. By Prof. E. S. Salmon.	Ditto, June, 1924.	Ditto.
‡Eighth Ditto. By Prof. E. S. Salmon.	Ditto, August, 1925.	Ditto.
Hop Experiments; The Testing of New Varieties of Hops. By R. G. Hatton and J. Amos.	Annual Report of the East Malling Research Station, 1924, pp. 169-175.	
Manurial Scheme of Trials with Hops. By J. Amos.	Ditto, 1924, pp. 176-179.	
FIELD TRIALS.		
Potatoes.		
Trial of Wart Resistant Potatoes. By R. G. Hatton and J. Amos.	Journal of the Kent Farmers' Union, Vol. vi., No. 5, p. 103, November, 1919.	
Variety Trials with Potatoes, 1919-20. By R. G. Hatton.	Ditto, Vol. ix., No. 1, p. 21, January, 1921.	
Ditto, 1921. By J. Amos.	Ditto, Vol. xi., No. 1, p. 20, January, 1922.	
Potato Trials at East Malling Research Station, 1923, By R. G. Hatton and J. Amos.	Journal of the Kent Farmers' Union, Vol. xiv., No. 5, p. 166, November, 1923.	
Potato Trials at East Malling Research Station, 1924, By R. G. Hatton and J. Amos.	Ditto, Vol. xvi., No. 5, p. 167, No. 6, p. 213, November and December, 1924, and Annual Report of the East Malling Research Station, 1924, pp. 189-194.	
Spraying Trials with Potatoes, 1918. By Prof. E. S. Salmon and H. Wormald.	Journal of the Board of Agriculture, Vol. xxvi., No. 1, No. 1, p. 71, April, 1919.	
Potato Spraying. " Three Years' Results at East Malling Research Station." By R. G. Hatton.	Journal of the Kent Farmers' Union, Vol. x., No. 1, p. 8, July, 1921.	

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Corn.		
Variety Trials with Oats and Barley. Spring, 1920. By R. G. Hatton.	Journal of the Kent Farmers' Union, Vol. viii., No. 6, p. 148, December, 1920.	
Wheat Trials at East Malling, 1921. By J. Amos.	Ditto, Vol. x., No. 3, p. 91, September, 1921.	
Winter Corn Trials (Wheat and Oats), 1921-22. By J. Amos.	Ditto, Vol. xii., No. 5, p. 164, November, 1922.	
Winter Oat Trials, 1922-23. By J. Amos.	Ditto, Vol. xiv., No. 5, p. 165, November, 1923.	
Corn Trials, 1923-24. By R. G. Hatton and J. Amos.	Ditto, Vol. xvi., No. 3, p. 93, September, 1924.	
METEOROLOGY.		
Meteorological Observations.	Contributed monthly to the Kent Farmers' Union Journal.	
Weather Conditions during 1924. By H. M. Tydeman.	Annual Report of the East Malling Research Station, 1924, p. 204.	
ANNUAL REPORTS.		
In 1914, 15, 16.	Brief leaflets outlining initiation of experiments, etc., were published as from "Wye College Fruit Experiment Station," Kent.	
In 1917, 18, 19.	Reports became fuller and were incorporated with those of the Research and Advisory Department, S.E.A. College, Wye, Kent.	
In 1920, 21.	After incorporation as an independent Research Institute reports were printed in the Journal of Kent Farmers' Union (December, 1920 and February, 1922).	
In 1922, 23, 24.	The Annual Report took the present form of independent publications. That for 1922 is now out of print. The 1923 Volume is still obtainable, price 3s. 4d.	
Popular Articles Contributed to Various Journals.		
Progress in Methods of Practical Fruit Growing. By R. G. Hatton.	Journal of Royal Agricultural Society of England, Vol. 82, pp. 49-117, 1921.	To be obtained only from Publishers, John Murray, Albermale St., London.
Fruit Growing in Small Gardens. By R. G. Hatton.	The Garden, Vol. lxxxviii., Nos. 2727, 2728, 2729, 2730, 2731, February to March, 1924.	
The Control of the Fruit Tree Through its Roots. By R. G. Hatton.	"Country Life," Vol. lv., No. 1430, pp. 867-869, June, 1924.	
Pruning Neglected Fruit Trees. By N. H. Grubb and A. W. Witt.	The Garden, Vol. lxxxviii., No. 2726, pp. 88-89, 16th February, 1924.	
"Notes to Fruit Growers."	Contributed monthly to Journal of the Kent Farmers' Union.	

*Joint Publication with Long Ashton Research Station.

†This Report was mainly the result of an investigation carried out at the S.E.A. College, Wye, and completed after Dr. Wormald's appointment at East Malling.

‡Reports issued from East Malling by E. S. Salmon, S.E.A. College, Wye, on data collected jointly upon Hops grown at East Malling.

No. 1. General View of Research Station, showing development to date.

From left to right: Orchard House and Preparation Room (1923-4), Propagation House and Fumigation Chamber (1923-4), Packing and Spraying Sheds (1920), Oast House (1922), Stabling and Old Laboratory (1914) (now Pathological Laboratory), Staff Annexe and Caretaker's Cottage (1923-4), and Physiological Laboratory, Library and Offices (1921).